JRC Scientific and Technical Reports

Scientific, Technical and Economic Committee for Fisheries (STECF)

Report of the Sub Group on Management Objectives and Strategies (SGMOS 10-06). Part c) Impact assessment of Western Channel sole multi-annual plan

SG-MOS 10-06 VIGO 18-22 OCTOBER 2010

Edited by John Simmonds, Sven Kupschus, Leyre Goti and Willy Vanhee

EUR 24630 EN - 2010

JRC EUROPEAN COMMISSION

ipsc Institute for the Protection and Security of the Citizen

The mission of the Institute for the Protection and Security of the Citizen (IPSC) is to provide research results and to support EU policy-makers in their effort towards global security and towards protection of European citizens from accidents, deliberate attacks, fraud and illegal actions against EU policies

The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

Contact information
Address: TP 051, 21027 Ispra (VA), Italy
E-mail: stecf-secretariat@jrc.ec.europa.eu
Tel.: 0039 0332 789343
Fax: 0039 0332 789658

https://stecf.jrc.ec.europa.eu/home
http://ipsc.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

JRC 61948

EUR 24630 EN
ISBN 978-92-79-18744-5
ISSN 1831-9424
doi:10.2788/55305

Luxembourg: Publications Office of the European Union

Printed in Italy

TABLE OF CONTENTS

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

STECF COMMENTS ON THE REPORT OF THE SUB GROUP ON MANAGEMENT OBJECTIVES AND STRATEGIES (SGMOS 10-06). PART C) IMPACT ASSESSMENT OF WESTERN CHANNEL SOLE MULTI-ANNUAL PLAN

STECF OPINION EXPRESSED DURING THE PLENARY MEETING (PLEN-10-02) HELD IN BRUSSELS, 8-12 NOVEMBER 2010

1. INTRODUCTION

STECF is requested to review the reports of the **SGMOS-10-06** Working Group of October 18 – 22, 2010 (Vigo) meeting, evaluate the findings and make any appropriate comments and recommendations.

When reviewing the SG-MOS 10-06b report, the STECF was asked to highlight limits faced when evaluating or assessing management options in terms of economic and social impacts. STECF will be also requested to suggest paths to reduce these limits, either by indicating possible assumptions which would be followed to make fisheries, metiérs and fleets matching better or by highlighting possible modifications to the list and to the level of aggregation of economic parameters listed in the DCF.

2. TERMS OF REFERENCE

The STECF (SG-MOS 10-06) is requested to

A) Evaluate the following plans:

1. Multi-annual plan for hake and Nephrops in ICES sub areas VIIIc and IXa
2. Multi-annual plan for cod in the Baltic

Following and taking into account *inter alia* the STECF framework specified in Annex C of SG-MOS 10-06a and WDs prepared by participants prior to the meeting. Separate reports should be prepared for each plan.

B) Provide an Impact Assessment of the following plans:

3. Multi-annual plan for sole in the Western Channel
4. Sole and plaice in the North Sea

by taking into account *inter alia*, the external report prepared by MRAG on assessing the impact for the revision multiannual plan for sole and plaice, WDs on sole and plaice prepared by IMARES, LEI, and WD prepared by CEFAS and Seafish on WC sole. The report should follow the STECF framework specified in Annex B of SG-MOS 10-06a. Separate reports should be prepared for each plan.

3. STECF COMMENTS AND CONCLUSIONS

Approach to the work

In line with the STECF process, described in the STECF-SGMOS 09-02 and STECF-SGMOS 10-01 WGs, STECF set up a scoping meeting SG-MOS 10-06a which was held in Copenhagen in June 2010. This group involved Commission staff, Observers and STECF experts. The scoping meeting produced a report (STECF-SGMOS 10-06a) which specified a series of work activities to be carried out before the October meeting. Following this Working Documents were prepared by participants for the main meeting which was held 18-22 October 2010 in Vigo, Spain. At this meeting there were 19 experts (6 economists and 13 biologists). Five Commission staff attended part time (including two from CFCA) and eight observers nominated by Baltic, NS, NWW and SWW RACs, Member States and ICES. The study group was open to observers throughout and their participation was regarded by the group as a particularly important part of this work. The working procedures were organised to facilitate observer participation by scheduling the presentation and discussion of topics on specific days to allow part time attendance if required. STECF is grateful for the input from observers.

Reports

In total five separate reports are prepared by STECF-SGMOS 10-06 WGs, the first, scoping meeting report STECF-SGMOS 10-06a was dealt with by the STECF summer plenary. The remaining four reports are deal with here:-

STECF-SGMOS 10-06b Report of the Impact Assessments for North Sea plaice and sole multiannual management.

STECF-SGMOS 10-06c Report of the Impact Assessments for Western Channel sole multiannual management.

STECF-SGMOS 10-06d. Report of the Evaluations of Southern hake and Nephrops Multi-annual plan

STECF-SG MOS 10-06e. Report of the Evaluations of Baltic cod Multi-annual plan

STECF provides below general comments and conclusions on this Impact Assessment the comments on other aspects of the ToR are included in the other reports (SGMOS 10-06b,d and e).

STECF Comments

Long term Objectives In the absence of B_{lim} of F_{lim} reference points it is difficult to evaluate the yields for WC sole in the context of appropriate risks for different exploitation rates of this stock. Nevertheless Fs in the range 0.2 to 0.27 provide robust options whilst providing reasonably high catches of sole. The probability of SSB being below B_{loss} rises rapidly if target Fs are at 0.3 and greater. Such probabilities attain high levels under some biological assumptions. In some of these high F situations long term risks are higher than short term risks indicating that these levels of F may be inappropriate strategies for exploitation if the aim is to have a lower risk of stock decline.

Fs between 0.2 and 0.27 give similar yields, though very slightly higher yields are found between F-0.25-0.27, suggesting that F_{msy} might be closer to 0.27 than 0.2.

Currently with the SSB close to a recent low and still below the historic B_{loss} (2700 t) all strategies have short term risks (low SSB up to 2115) due to natural variability in recruitment.

No bioeconomic models are available to indicate economic responses different from maximising landings.

Strategy options: Constant TAC targets give either lower yield for the same risks as F strategies or higher risks for the similar yields.

Constraint to inter-annual variability in TAC is associated with a slight reduction in target Fs slightly below F_{msy}.

Banking and then paying back up to 10% of the TAC has no important impact on long term risks.

Assessment: In the past the ICES Assessment has not been available: A survey is available to give an index of the exploitation rate should the ICES assessment become unavailable. Increased measurement error is associated with increasing risk and declining yields.

ANNEX 1. THE REPORT OF THE SUB GROUP ON MANAGEMENT OBJECTIVES AND STRATEGIES (SGMOS 10-06). PART C) IMPACT ASSESSMENT OF WESTERN CHANNEL SOLE MULTI-ANNUAL PLAN

SUMMARY

THE SGMOS 10-06 met Copenhagen in June 2010 and produced a scoping plan for the historic Evaluation of the Western Channel sole multi-annual plan. The group met again in Vigo between 18-22 October 2010 and prepared this report for the November 2010 plenary of STECF. Based on the evaluation carried out the group came to the following conclusions:-

In the absence of reference points it is difficult to evaluate the yields in the context of appropriate risks for specific exploitation rates of this stock.

Currently with the SSB close to a recent low and still below the historic Bloss all strategies have short term risks due to natural variability in recruitment

Constant TAC targets give either lower yield for the same risks as F strategies or higher risks for the similar yields.

Risks rise disproportionately if target Fs are at 0.3 and greater, and attain high levels under certain biological assumptions. In some situations of this type long term risks are higher than short term risks indicating that these may be inappropriate strategies for exploitation if the aim is to lower risk.

Fs between 0.2 and 0.27 give similar yields, though very slightly higher yields are found between F-0.25-0.27, suggesting that this Fmsy might be closer to 0.27 than 0.2.

Constraint to interannual variability in TAC is associated with a target Fs slightly below Fmsy, because catches would need to be reduced more rapidly than is possible in order to ensure the sustainability at the higher F levels.

Banking and then paying back up to 10% of the TAC has no important impact on long term risks.

Increased measurement error is associated with increasing risk and declining yields.

In the absence of any specific risk avoidance criteria it is not possible to give specific target advice, but Fs in the range 0.2 to 0.27 provide the most robust options whilst providing reasonably high catches of sole.

No bioeconomic models are available to indicate economic responses different from maximising landings.

1. INTRODUCTION

This report is one of four prepared under SGMOS 10-06b, each dealing with a separate item on the ToR below. The work followed the plans from the Scoping meeting SGMOS 10-06a Copenhagen 7-11 June 2010. This report follows the structure defined by STECF which is given below in Appendix A.

2. TERMS OF REFERENCE

The STECF (SG-MOS 10-06) is requested to

A) Evaluate the following plans:

1. Multi-annual plan for hake and Nephrops in ICES sub areas VIIIc and IXa

2. Multi-annual plan for cod in the Baltic

Following and taking into account *inter alia* the STECF framework specified in Annex C of SG-MOS 10-06a and WDs prepared by participants prior to the meeting. Separate reports should be prepared for each plan.

B) Provide an Impact Assessment of the following plans:

3. Multi-annual plan for sole in the Western Channel

4. Multi-annual plan for Sole and plaice in the North Sea

by taking into account *inter alia*, the external report prepared by MRAG on assessing the impact for the revision multiannual plan for sole and plaice, WDs on sole and plaice prepared by IMARES, LEI, and WD prepared by CEFAS and Seafish on WC sole. The report should following the STECF framework specified in Annex B of SG-MOS 10-06a. Separate reports should be prepared for each plan.

The scoping meeting is reported in SG MOS 10-06a. The Evaluations are dealt with in reports SG-MOS 10-06d, e and the Impact Assessments for North Sea plaice and sole in SG MOS 10-06b.

3. PARTICIPANTS

Name	Address	Telephone no.	Email
STECF members			
Willy Vanhee	Hospitaalstraat,8400,Oostende, Belgium	+32 59433083	wvanhee@pandora.be
External experts			
Heleen Bartelings	Alexanderveld 5 2585 DB The Hague	+31(0) 703358320	heleen.bartelings@wur.nl
Jörg Berkenhagen	vTI-Inst. Sea Fisheries, Palmaille 9, 22767 Hamburg, Germany	+4940 38905206	joerg.berkenhagen@vti.bund.de
Jose Maria Da Rocha Alvarez	Campus Lagoas Marcosende, 36200,Vigo,Spain		jmrocha@uvigo.es
Margit Eero	Charlottenlund Castle,DK-2920, Charlottenlund, Denmark		mee@aqua.dtu.dk
Leyre Goti	General Concha 44, 4ºcentro izda, 48012,Bilbao,Spain		leyregoti@yahoo.com
Joakim Hjelm	Turistgatan 5,SE-45321, Lysekil, Sweden		joakim.hjelm@fiskeriverket.se
Tore Jakobsen	Nordnesg. 50,5005,Bergen,Norway		tore.jakobsen@imr.no
Sven Kupschus	Pakefield Road,NR33 0HT, Lowestoft,United Kingdom	+441502 524454	sven.kupschus@cefas.co.uk
David Miller	Haringkade 1,1976 CP, IJmuiden, Netherlands		david.miller@wur.nl
Arina Motova	S. Konarskio str. 49,LT-03123, Vilnius, Lithuania		arina.motova@erpi.lt
Rasmus Nielsen	Charlottenlund Castle, Jaegersborg Allé 1, DK-2900, Charlottenlund, Denmark	+ 4533963381	rn@aqua.dtu.dk
Tom Peatman	MRAG Ltd, 18 Queen St., London W1J 5PN	+44 2072557784	t.peatman@mrag.co.uk
Tiit Raid	Estonian Marine Institute, University of Tartu, Estonia		tiit.raid@gmail.com
Cristina Silva	Av. de Brasília,1449-006,Lisboa, Portugal	+351 213027096	csilva@ipimar.pt
Valentin Trujillo	IEO, CO de Vigo Cabo Estay – Canido, Apdo 1552, E-36280 Vigo Espania		valentin.trujillo@vi.ieo.es
Christopher Zimmermann	vTI-Inst. Baltic Sea Fisheries, Alter Hafen Süd, 18055 Rostock, Germany	+49 3818116115	czimmermann@clupea.de
JRC experts			
Robert Scott	Via E.Fermi,21027,Ispra,Italy	+390332 783692	robert.scott@jrc.ec.europa.eu
John Simmonds	Via E Fermi,21020,Ispra,Italy	+390332 785311	john.simmonds@jrc.ec.europa.eu
European Commission			
Rodrigo Ataíde Dias	Rue Joseph II 79,1000, Brussels, Belgium		rodrigo.ataide-dias@ec.europa.eu
Peter Hopkins	Rue Joeseph II 79,1049, Brussels, Belgium		peter.hopkins@ec.europa.eu
Anna Zaradna	Rue Joseph II, 79,1049, Brussels, Belgium	+3222987481	anna-maria.zaradna@ec.europa.eu
CFCA			
Vincent Esclapez	CFCA, Garcia Barbon ,36201,Vigo, Spain	986 12 06 63	vincent.esclapez@cfca.europa.eu
Mario Santos	CFCA,Garcia Barbon ,36202,Vigo, Spain	987 12 06 63	mario.santos@cfca.europa.eu
Observers			
Manuela Azevedo	H.C Andersens Boulevard 44-46,DK-1553, Copenhagen, Denmark	+45 33386700	manuela@ices.dk
António Cunha	Av. Marginal,3830-552,Gafanha da Nazaré, Portugal		antonio.cunha@testacunhas.pt
Magnus Eckeskog	Åsögatan 140,116 24,Stockholm, Sweden	+46(8)250790	magnus.eckeskog@fishsec.org
Reine Johansson	H.C. Andersens Boulevard, 1553, Copenhagen, Denmark	+45 33935000	ai@bsrac.org
Geert Meun	Vlaak 12,8321 RV,Urk,Netherlands		gmeun@visned.nl
Jim Portus	Westbeer House 50 Fore Street Ivybridge Plymouth, Devon UK, PL21 9AE,		swfpo@btinternet.com
Roar Schou	H. C. andersens Boulevard 37, 1553, Copenhagen, Denmark	+45 33935000	rbs@nexohavn.dk
Cristina Rosa	Direcção-Geral das Pescas e Aquicultura, Av. de Brasília, 1449-030 Lisboa, Portugal		crosa@dgpa.min-agricultura.pt

4. PROBLEM STATEMENT

In 2003 ICES and STECF advised no fishing on the stock of sole in the Western Channel unless a recovery plan was in place. The Commission proposed such a recovery plan (also including the Bay of Biscay sole) in 2003.

The Council then established a multiannual plan for the exploitation of the stock of sole in the Western Channel in 2007. However, effort management was introduced in 2005, which can be taken as effective date of entry into force. The management plan was adopted to reduce fishing mortality and increase SSB in this stock.

The rate of progress towards the targets of the management plan were to be evaluated in 2009 and in each third successive year. However, in 2009 ICES advised that the management plan for Western Channel sole could not be evaluated because there was no available analytical assessment or biological reference points. Because of this, the implementation of the plan was suspended in 2009.

Now that analytical assessments are again available for this stock, it is appropriate to review the plan.

5. OBJECTIVES OF THE PLAN

Council Regulation (EC) No. 509/2007 established a multi-annual plan for the sustainable exploitation of sole in the Western Channel. Years 2007–2009 were deemed a recovery plan, with subsequent years being deemed a management plan.

The target fishing mortality set in the plan was to exploit the stock with a fishing mortality rate of 0.27. No additional considerations have been taken since the implementation of the plan and the plan remains species-specific.

The objectives of plan can be categorised into biological, environmental and socio-economic.

The principal biological objective is to fish the stock at mortality rate consistent with Fmsy by 2015, and to maintain that rate in subsequent years with a low risk that the stock may fall outside safe biological limits in the medium term. A secondary biological objective might be to reduce discards.

The environmental objectives should be that the plan is consistent with the achievement of good environmental status by 2020.

The socio-economic objectives are to provide stability by constraining inter-annual variations in TAC. Another economic objective might be to move towards maximum economic yield, though this would require a clear definition of the group or groups for which the economic benefits are maximised.

6. CHOICE OF TACTICAL METHODS

Combination of TAC and effort control

7. OVERRIDING CONSIDERATIONS OF THE OPTIONS

The options presented in this report have mainly concentrated on alternative biological and assessment error assumptions to evaluate the robustness of sustainability to different long term management targets under the different biological assumptions.

In this context there are two considerations, first the current ICES advice and the data to parameterize the models used here is based on an assessment methodology that has not been reviewed by a full benchmark process and therefore the assessment basis of future advice is not yet certain. However, results from the ICES assessment were seen to be similar to previous assessments and give similar historic perception of the stock and its exploitation. Thus they provide some guidance on suitable targets and ways forward for the management of Western Channels sole. Only a limited number of scenarios have been tested. Thus there may be other options that could be considered. If there are to be major changes to the management approach, it may be useful to evaluate alternatives that focus on specific question that may not have been fully answered here.

As the status assessment is uncertain it is possible that the basis of the ICES advice may change in the near future. However, in the absence of suitable assessment results, it should be acceptable to assess relative trends in F from survey information as evaluated by SG-MOS 09-02. Given the currently available information that F is at or very near the long term management target of the current management plan, this should be sufficient to at least evaluate the relative change in exploitation into the future, even in the absence of a full analytical assessment.

There is a general acceptance by ICES that the perceived risk to the stock is largely based on the historic choice of reference points, whilst more general indicator of stock status such as the age structure of the stock and abundance estimates from surveys suggest that the stock is not in imminent danger of collapse. Furthermore, there is little doubt that the stock has been over exploited in recent history with respect to maximizing long term yield and ensuring long term sustainability (WKFLAT 2009, SG-MOS 09-2). In the absence of any formally recommended precautionary limit or reference point in carrying out this impact assessment STECF has used risk of SSB < Recent low SSB as the main risk criteria. Without formal reference points the evaluations here are based on an approach that avoids exploitation that take the stock lower than previously observed but does necessarily reflect risk of stock collapse.

8. ENVIRONMENTAL EFFECTS OF THE OPTIONS

The numerical basis of the evaluations is the 2010 ICES assessment output. A stochastic forecast simulation was performed on the basis of a number of alternate assumptions about recruitment, assessment error and the likely divergence between advice and implementation. A description of the variables used to simulate these factors and the way they have been implemented is available in Annex B where a table of all the setting simulated are also shown (Table B1).

Assumptions about future recruitment have a major impact on the likely future yield of the stock and our perception of its resilience. There is little evidence of an obvious break point in the SSB where recruitment becomes impaired, nevertheless it is reasonable to assume that such a break point must exists and that its effect will be altered by the prevailing environmental condition. Three SSB brake points have been chosen in these simulations, 2278t, 2800t and 4000t. These are consistent with recent observed low SSB, historic Bloss, and the statistical fit of the hockey stick regression to the current rather limited range of SSB from the assessment data. The lowest of these breakpoints (2280 t and mean historic recruitment) implies a slope in the S-R relationship of R/SSB = 2.0. This compares with the range of slopes to fitted using hockey-stick S-R relationships for NS sole (SGMOS 10-06b) of between 2.5 to 7.0, with a mode at 4.1. This distribution maps to the WC sole SSB as < 1700t with the upper 95 percentile or 1100 t as the modal value. This suggests that the use of data derived breakpoints and Bloss type precautionary biomass limit point to be avoided may be excessively precautionary.

In addition to the main functional relationship, some provision has been made to simulate different degrees of temporal auto correlation in the recruitment trends mimicking long term environmental effects.

Uncertainty in the assessment process are simulated at different levels of variability and temporal bias (appropriate for this stock, as it has suffered from a significant retrospective bias in recent history). Permanent or fixed bias in assessment results is implemented in the simulation framework, but has not been examined in this work.

Two management strategies, constant F and constant TAC, have been evaluated at different levels of exploitation under these various biological and assessment assumptions which allows comparisons of the conditional yields and risk from each scenario. Additional management measures that have been investigated are constraint in the variation of TAC and TAC banking, although different levels of these have not been investigated.

Risks are define at three points

- Short term the risk of being below the Biomass point in 2015 (a single year)
- Medium term the risk of being below Biomass point at least once in 2016-2025 (10 years)
- Long term the risk of being below Biomass point at least once in 2026-2035 (10 years)

As the short term risk is defined for a single year the risk values for short term do not translate directly to the medium and longer term values. Comparing risk in the medium and longer term indicates if a strategy is generally expected to improve stock status or not into the future. This is important as the stock is currently recovering from a low SSB.

Seventy four combinations of settings (runs) were carried out as part of this work, which clearly is well short of the full set of permutations in terms of reasonable biological assumptions and management options. However, the simulations are considered sufficient to rank the order of importance of the various uncertainties in the biological conditions and assessment parameter estimates and if required these can be used to focus areas of future investigation on management options once more guidance on preferred measures is available. Input and output information in terms

for the simulation is available in files (.csv) on the ftp site for landings, SSB, recruitment and F and the proportion of landings in each size category, and summarised in terms of graphs (.wmf) for each run. In this report only a very small number of examples are provided in full and most of the report concentrates on the trends in the median stock dynamics (50 % percentile) results and the risks (number of simulations out of a total of 500 falling below recent low SSB = 2278t).

The simulation framework programmed in the FLR framework specifically for this work. As an additional check on the programming the results of the stochastic simulations were compared to a stochastic equilibrium yield analysis (Annex C). Suggested long term management targets and their corresponding yields were very much in agreement between the two analyses suggesting that the basis of simulation framework is at least numerically correct. No specific confirmation exists if the implementation of variance and bias function as intended but these results appear coherent with other work.

The basis of the assumptions and the management options to run were agreed at SGMOS 10-06a (STECF 2010) held in Copenhagen in June

The main biological fishery and assessment error assumptions are defined in Annex B and tabulated by run. Briefly they consist of recent selection (last 10 years) recent weights at age in catch and stock (10 years). S/R functions with breakpoints at 2780, 2800 and 4000. Recruitment above the breakpoint historic mean (all), low and high periods and with auto correlation.

Table 8.1: Parameter values and Run identification number of simulation runs with alternate assumptions about recruitment at F=0.27. Unimpaired median recruitment occurring above SSB inflection point at different biomass levels shown (The two assumptions are implemented independently in the stochastic simulations). Full details of all run setting are found in Appendix B Table 1. * autocorrelated recruitment is simulated using the same data period as 'all' but splits the recruitments between low and high with a finite probability of changing from one subset to the other (see appendix B plots). The realized mean recruitment is slightly higher than for uncorrelated results.

		SSB inflection point			
		min (SSB)	ex Bpa	statistical HS fit	
	Unimpaired Recruitment	2278	2800	4000	
		Run No			
All	4332	62	43,64,66,70,71,72,73,74	22	
autocor *	ca. 4332	5,49,63	44,65,67,68,69		
Low	4100	41			
High	5106	37			

8.1. Evaluation of the effects of the multi-annual plan options on the fishery

8.1.1. Choice of main Management strategy for setting a TAC:

Two types styles of TAC setting regime were evaluated, a constant TAC which is maintained until the stock is seen to decline too far or risks rise too high, and a constant Fishing mortality (F) regime taking a proportion of the stock. Compared with the F regime constant TAC management produced lower levels of yield at the same levels of risk. This is true in the long term, but the effect is much more pronounced in the short term due to the current status of the stock associated with the recent over exploitation. Constant TAC scenarios are advantageous to fishermen in planning future strategies and investments. However given the multi-species nature of the fishery and the variability in availability and price of other resources exploited by the fishery, the benefits of certainty in future income from sole provided by a constant TAC strategy is outweighed by the lower levels of yield at certain loss of future income compared to constant F strategies.

For example under a plausible set of biological and assessment assumptions the median sustainable constant yield from the stock is around 600t under a constant TAC scenario where as F target strategies in the median deliver over 800t for the same risk (Figure 8.1).

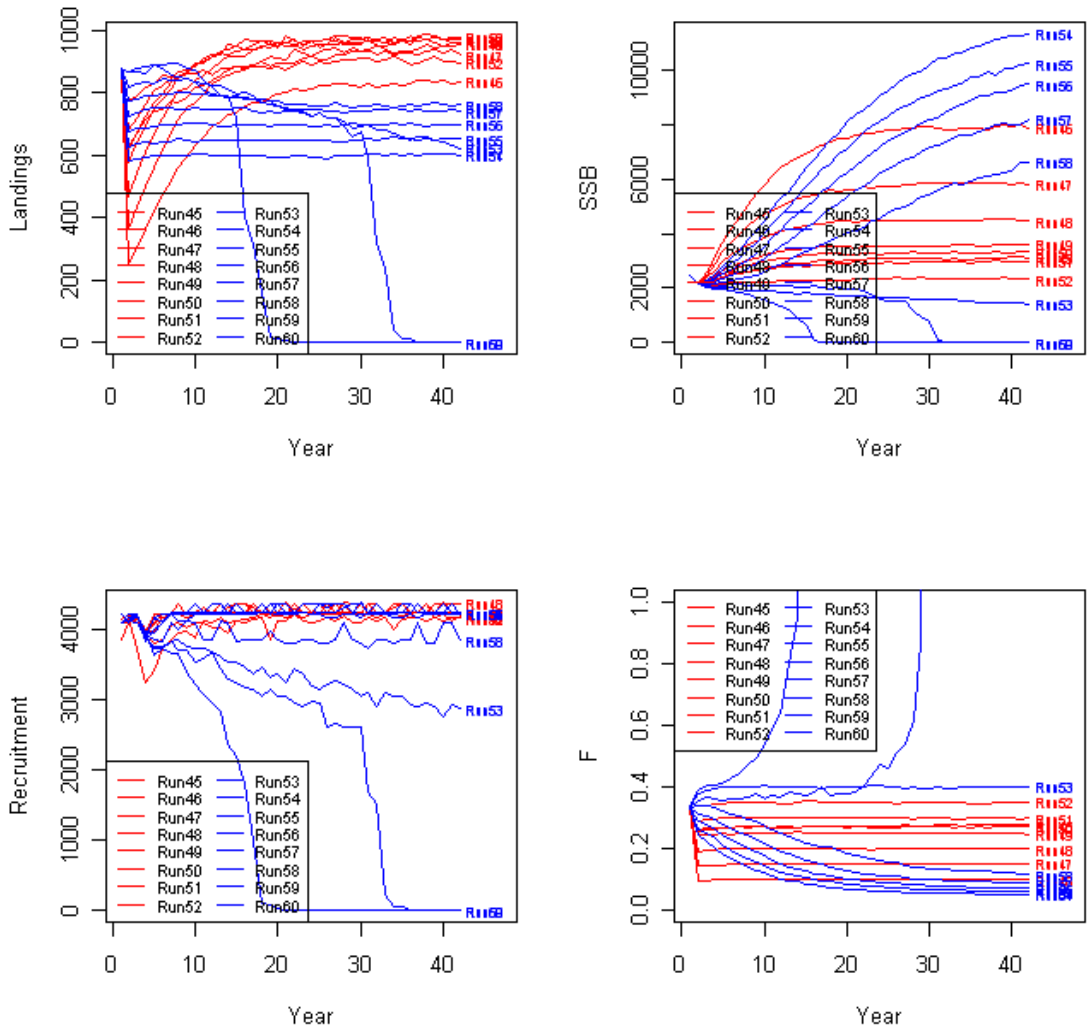

Figure 8.1:Median stock dynamics provided by two management strategies (red = F-target over the range of 0.1-0.4, blue = constant TAC over the range of 600 – 1000t).

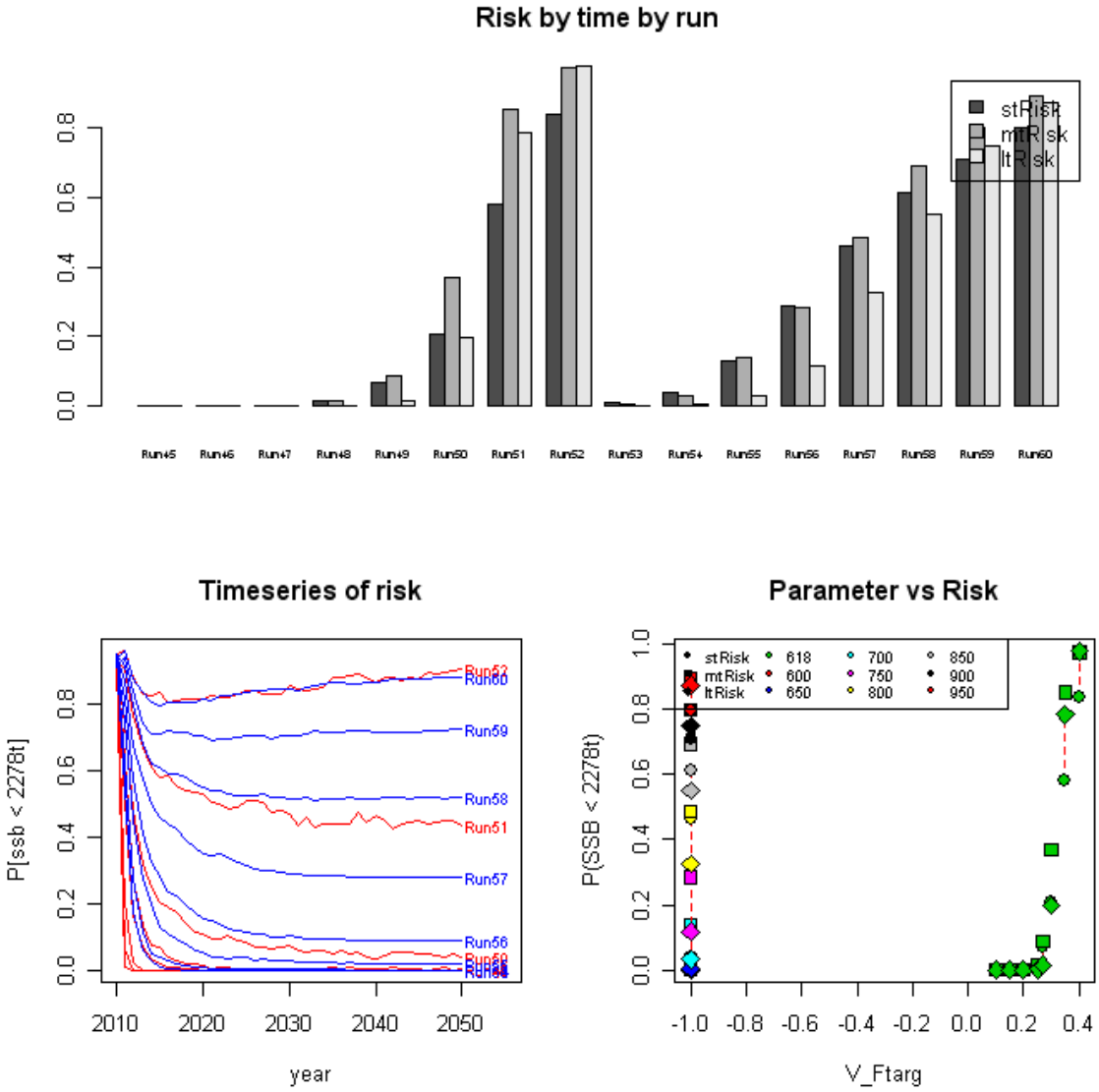

Figure 8.2:Risk evaluation for two management strategies (red = F-target over the range of 0.1-0.4, blue = constant TAC over the range of 600 – 1000t). Top Figure represents the risk for SSB < Bloss at least once in the short term (2015), in the medium term (2016-2025) and long term (2026-2035)

8.1.2. Choice of the level of the management target:

Given that at least in the medium term an F based management strategy is advantageous an appropriate level of F needs to be determined. Yield and risk here is highly dependent on the assumption of the stock recruit relationship.

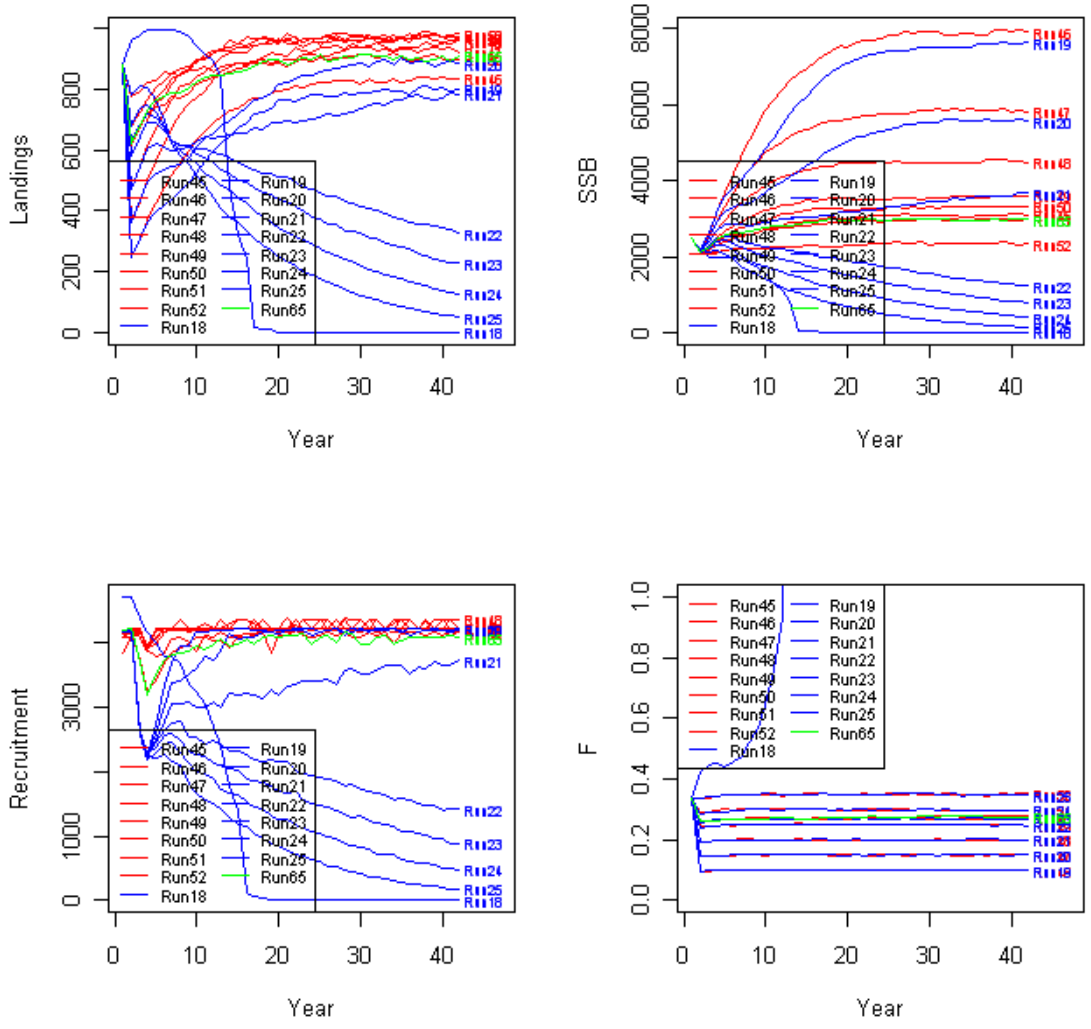

Figure 8.3:Median stock dynamics provided by different levels of F (two management strategies (red = F-target over the range of 0.1-0.4, blue = constant TAC over the range of 600 – 1000t).

Under the assumption that the stock recruit inflection point is at 4000t only very low levels of F are sustainable because recruitment is continually impaired by current low SSB values. At lower levels of the SSB inflection point on the stock recruit relations (ie levels below 3000t) F levels up to 0.4 maintain high median yields. A break point of 2800t, consistent with the most recent ICES advice on this stock, gives a long term equilibrium SSB levels of around 3000t which is close to the assumed break point in the stock recruit relationship.

I all cases the short term risk is quite high especially for those scenarios where the current status of the stock SSB is below the inflection point, however the risk substantially decreases by 2015 in most scenarios where F is below 0.3 except for those with the higher s-r break point of 4000t, or those assuming large assessment error and implementation bias.

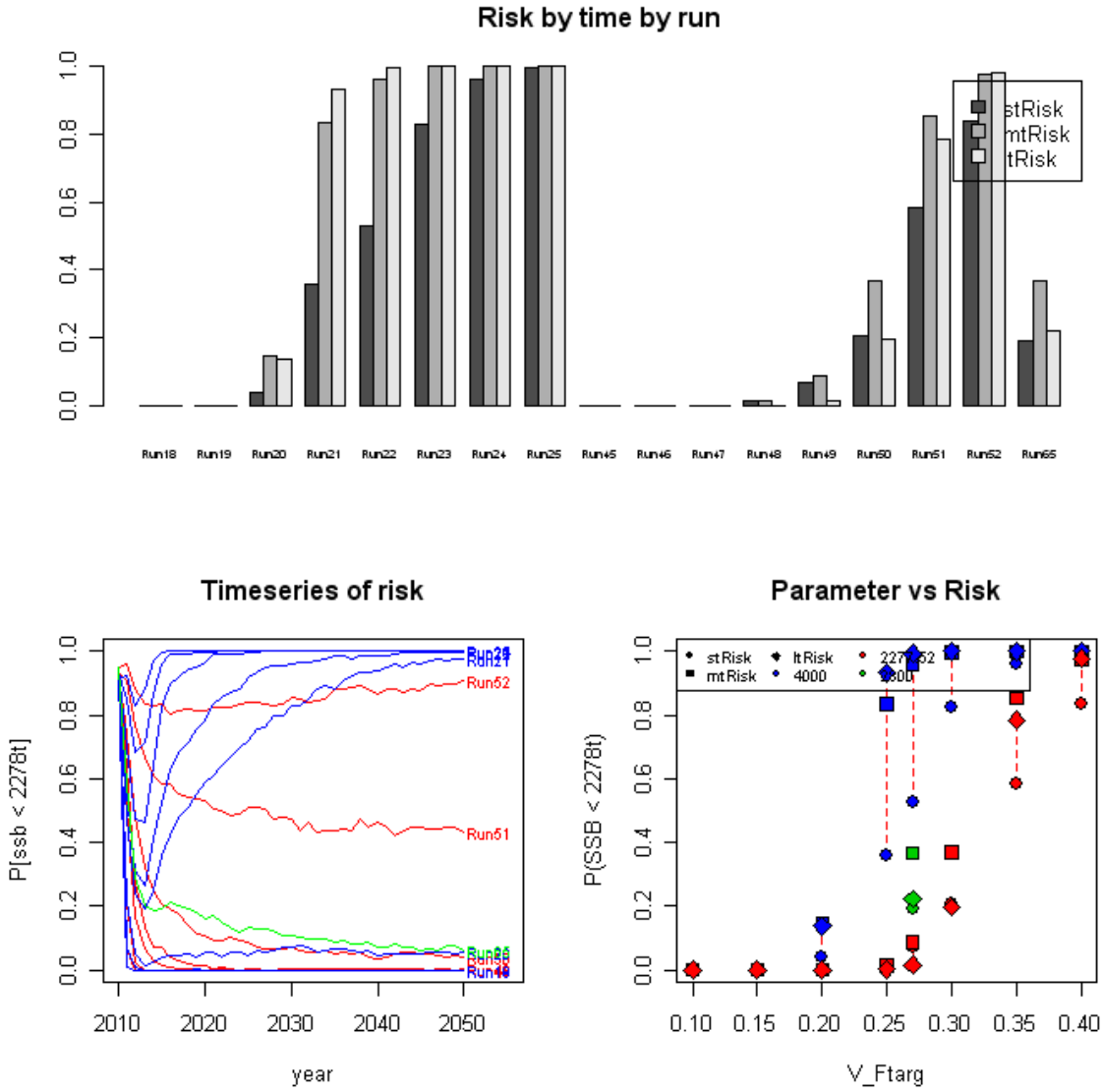

Figure 8.4:Risk evaluation for different stock recruit break point assumptions (red = Bloss, 2278t, blue = 4000t, green = 2800t). Top Figure represents the risk for SSB < Bloss at least once in the short term (2015), in the medium term (2016-2025) and long term (2026-2035)

8.1.3. Effect of Assessment uncertainty:

Both variance and bias components of the uncertainty in the assessment outputs were examined by adding a variance component to the F estimate in calculating the following years TAC for scenarios for a long term target F of 0.27. Error is considered to have two components:-

- a bias which is applied as a probability of the error in one year being the same as the previous year
- a variance component defined by its standard deviation applied as multiplicative error expressed as a normal distribution in the log domain.

As the variance component increases the short term risk increases. In terms of long term risk the same pattern is true, but the risk is considerably lower, because it is expected that with a target of F=0.27 stock biomass will increase to levels away from Bloss. The effect of bias is that the higher the likelihood of persistent bias in assessment parameters the higher the risk to the stock, because of the longer period over which the stock is exploited away from the target value. With a low likelihood of persistent bias the short term risk is similar to the long term risk and the risk is largely independent of the variance component. Long term risk increases both with increasing bias persistence and increasing variance interactively.

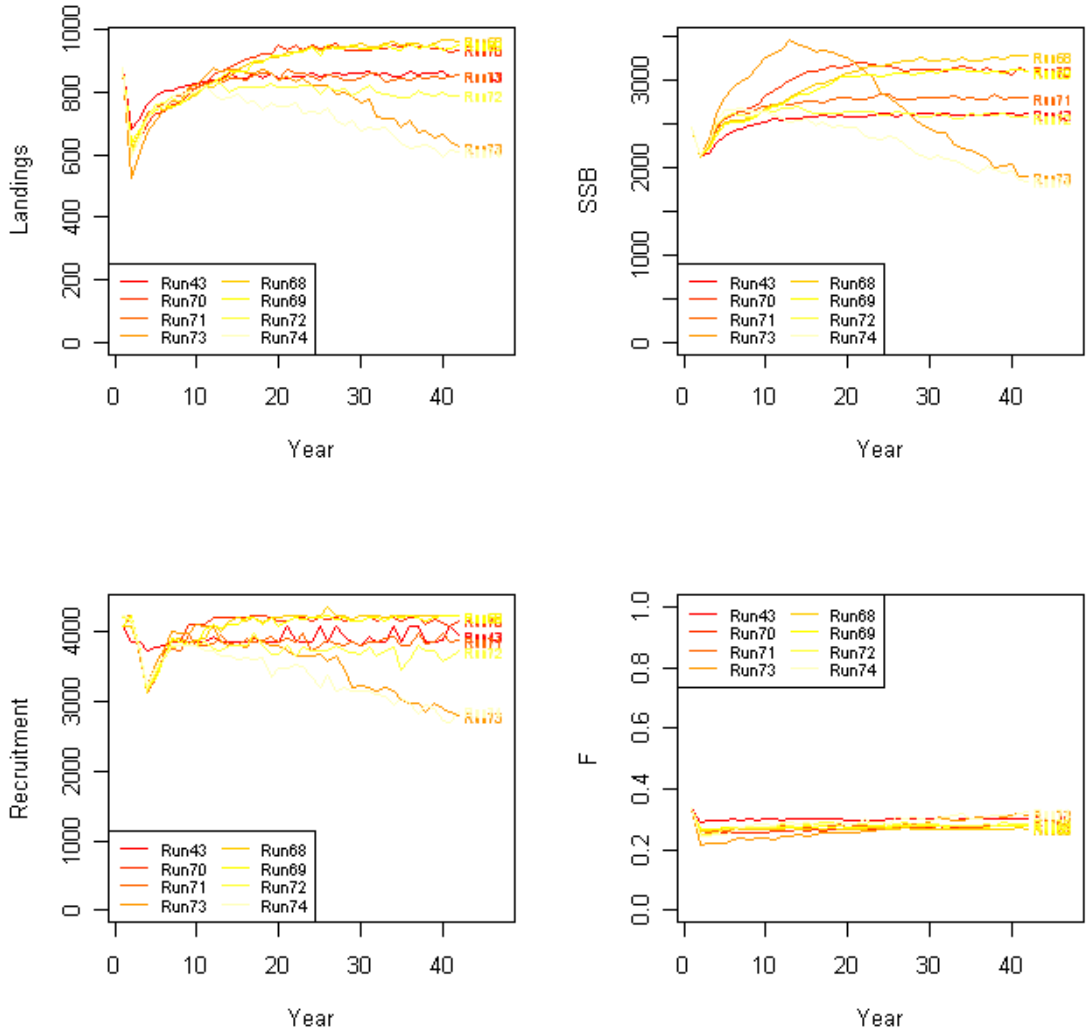

Figure 8.5:Median stock dynamics provided at F=0.27 for different assumptions about the variability and bias in stock assessment parameter estimates.

Generally the evaluation of the long term risk indicates that the level of F=0.27 is robust to the likely range of assessment error, however, in the short term risk are higher for some error scenarios. These risks decline over time as the stock biomass

increases under this exploitation rate. If it is necessary to avoid these elevated short term risks this would either require further work on better estimating the actual assessment error or additional management measures that reduce risk in the short term.

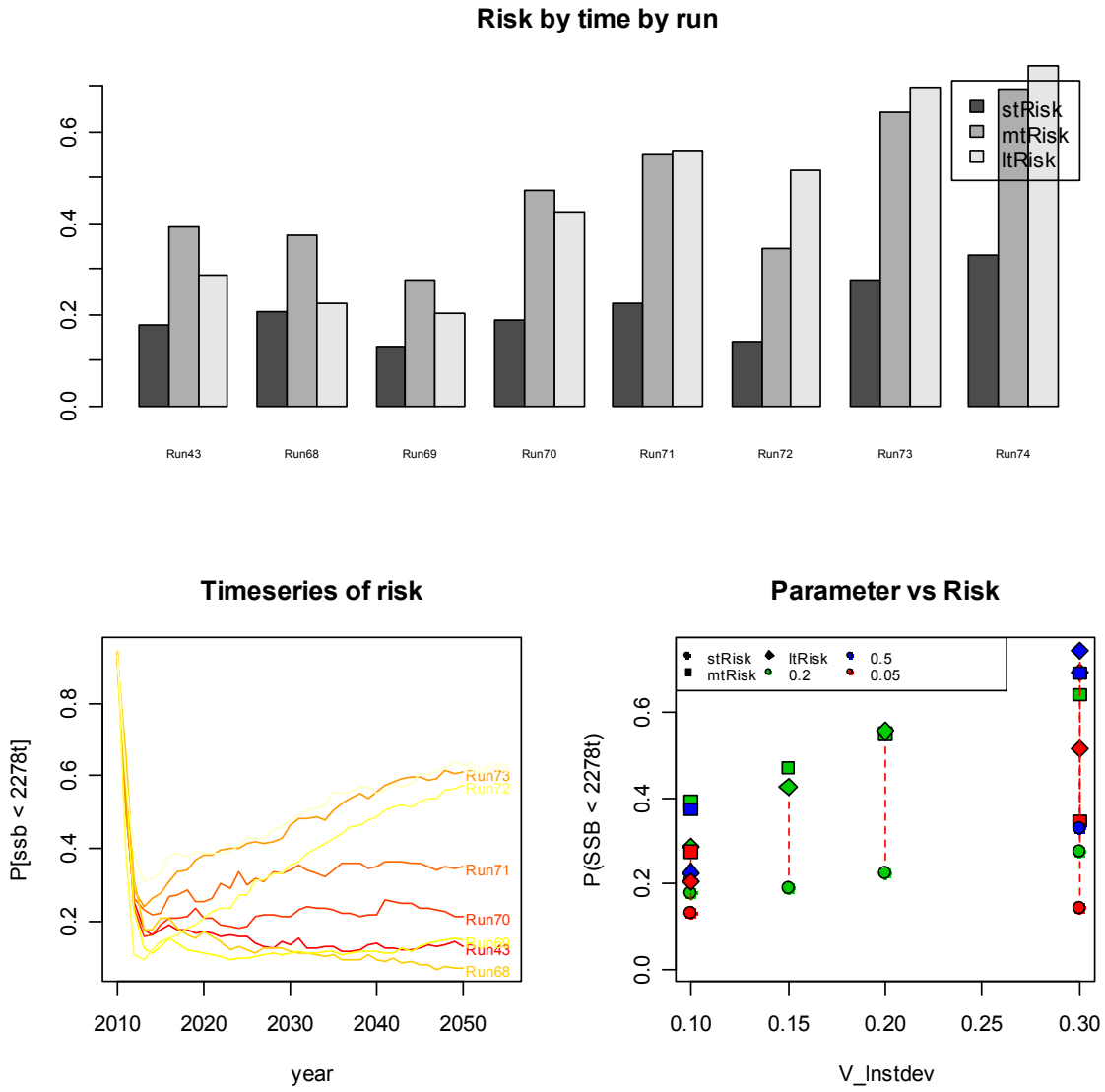

Figure 8.6: Risk evaluation for different stock recruit break point assumptions (see Appendix B for setting chosen). Top Figure represents the risk for SSB < Bloss at least once in the short term (2015), in the medium term (2016-2025) and long term (2026-2035)

8.1.4. Summary of management options:

The largest effect on yield and risk is the choice of management strategy. In many ways the large difference in yield is associated with the high short term risk given the

current state of the stock. Potentially higher yields would be attainable in a constant catch scenario once the stock is in a better state. However, given the multi species nature of this fishery and its high dependence on already variable catch components it seems unlikely that a constant catch strategy would be favoured and it would considerably reduce flexibility in management if stock dynamics were to move outside the current range of observed values.

Assumptions about recruitment have the largest effect of constant F strategies in terms of risk and SSB. Yield is largely unaffected over most of the range exploitation examined here except for the lowest and highest vales (0.1 and 0.4), because of the very flat-topped nature of the yield per recruit curve. Risk of stock collapse (SSB< low recent biomass) is closely linked to the assumption of breakpoint on s-r relationship and the F target for the plan.

Assuming an F of 0.27 is sustainable and maximizes yield from the fishery in general, we investigated the chance of managing the fishery effectively at these exploitation levels given the uncertainty in assessment and implementation error (These simulations assume the currently advised recruitment inflection point of 2800t). The size of the current assessment error or its bias are unknown, but values chosen over a likely range indicate that under certain assumptions is greater than what is considered to be precautionary in the short term whilst long term risk is largely robust to the assumptions about error tested here. The short term risk is largely a consequence of the current state of the stock because the management plan only appears only to have been effective in reducing F (F in 2009) since the introduction of the single area license scheme by the UK in late 2008. Therefore there may be a need to examine lower levels of exploitation which will not significantly affect the yield of sole in the long term, but will significantly reduce the yield of other species taken in this multi species fishery. Alternatively, some short term measures that increase the rate of rise of SSB to more favourable levels should be considered.

8.2. Evaluation of the effects of the options on the stock

Only a small number of actual management options were investigates here. The conclusions are that levels of F=0.27 will increase SSB to respective precautionary levels irrespective of the assumed recruitment relationships. Long term median SSB is estimated to be significantly higher if median recruitment is higher, but these differences are in line with the assumed precautionary levels (based on current ICES advice , but see section 8). Risks are well above 5% for the higher breakpoint in S-R relationship and higher measurement errors.

8.3. Evaluation of the effects of the multi-annual plan on the ecosystem.

An F target of 0.27 will provide median yields equivalent to those obtained by lower levels of F (0.2-0.27) but do so at a higher risk, suggesting that lower levels should be a preferred option, but this does not consider the multi species nature of this fishery, which economically is an important component of the fishery, see section 9. Catches of cuttlefish, angler fish, scallops and plaice provide important components

of the fishery. Because of the very wide distribution comparatively even distribution of sole within the area it is not possible to entirely spatially separate the catches of these species from sole although spatial management may achieve favourable improvements in the catch ratio.

9. SOCIAL AND ECONOMIC EFFECTS OF THE PLAN

9.1. Methodology and data

There are no explicit socio-economic objectives defined by the multi-annual plan so the considerations are those of the general socio-economic objectives as stated in the CFP. Possible methodologies and the characteristics of the available economic data have been explored. In addition where possible economic indicators as defined in Annex A of this report are calculated and presented below

9.1.1. Economic Data

The economic data available for the firms involved in the Western Channel sole fishery comes from the SEAFISH 2008 Economic Survey of the UK Fishing Fleet. The data comprises DCF variable as well as additional indicators and methodology issues.

Economic indicators are calculated for the two fleets for which economic data are available (South West beamers below and over 221kW) that account for around 75% of UK catch. Additional data on volume of catch, value of catch and dependence on 7e sole highlighting the representativeness of the economic data from those two fleets can be found in appendix C. However, the spatial area covered in the data goes beyond the area under the management plan, as the former refers to the South West and English Channel as a whole.

9.1.2. Economic methodology

A bio-economic model for the area has not been developed yet, although work is being done by SEAFISH to establish such a model (see report from SGMOS 10 06a), Only indicators (see below) have been calculated, and the analysis thus assumes a basic static approach as a description of the impact of the management plan in 2008. Further analyses as a valuation of a decrease in TAC at current prices could be performed to quantify the income to be "regained" by exploiting other species or moving to different areas. Considerations for future analyses including spatial and social aspects are given below in Section 12.

9.1.3. Economic indicators

Economic and social indicators have been produced to assess the impact of the management plan using the available data and following the definitions suggested in the "Framework for impact assessment report" (see Appendix A) The multi-annual plan has social and economic effects as it affects not only the way companies can design strategies to attain the profits they need for subsistence, but also the economic and social environment where the companies operate. Economic indicators are calculated for the two fleets for which economic data are available that account for around 75% of UK catch.

Economic Indicators	<221 kW	>221 kW
Fleet composition (no. vessels)	21	27
from which fishing in 7e for sole	17	26
Value of landings	346023	524982
Market price	2.78	2.64
Gross Cash Flow (GCF)	24521	82813
Break Even Revenue (BER)	347385	491424
Gross profit	-1142	46158
Gross Value Added (GVA)	111496	224547
Return to be shared	190018	325844

Despite the relative similarity of the segments the differences in profitability can be due to the more varied catch composition of the >221kW and its larger capacity to access areas further from port, which, at the similar market prices gives the segment of >221kw vessels a higher productivity per day which is reflected in their economic performance.

9.1.4. Social indicators

Social indicators	<221 kW	>221 kW
Employment total per segment	88	113
Employment per vessel	4	4
Wages per segment	1826474	3826816
Wages per vessel	86975	141734
Wages per employee	20755	33866

The employment in both types of vessels is similar, and the higher productivity mentioned above allows for higher wages per employee.

Further implications of the impact of the Western Channel management plan for sole can be developed from the qualitative analysis in the next section.

9.2. Interactions that influence the effect of the MAP

As explained above (section 9.1.2) the social and economic impact of the multi annual management plan cannot be quantitatively assessed due to the nature of the fishery and the lack of a model. There is nevertheless room for describing the biological, social and economic interactions occurring in the fishery that should be taken into account as they influence the social and economic impact of the multi-annual management plan[G]

9.2.1. Biological and economic interactions

Sole is the main species economically because of its price and demand [SEAFISH rep]. It is also attractive to the fishermen from a supply point of view for its reliability, and this is due to its biological characteristic. Sole is relatively predictably available on the same areas and throughout the year. Other species that have started to be exploited more recently, such as scallops and cuttlefish, complement the revenue for the fishermen, but their higher spatial and temporal variability make them a less certain and hence more problematic economically.

The most demanded size for fish in the case of the UK sole fishery in the 7e area are the intermediate ones (categories 2-5 [ ]), with smallest fish having the lowest value and fish of the highest age categories having higher value than the smallest, but still lower than the intermediate ones. Therefore there is a match between the age categories that are most valued by the market and those that do no harm the stock. [This may also have implications for discards due to lower economic value but also to a more favourable position of the fishermen towards higher selectivity measures, as small size sole is not valued] [However this situation does not apply to the Belgian fishery, were smaller fish have a higher value.]

The closing of some areas to fishing for environmental reasons under proposal by the UK government may reduce the fishing opportunities for scallops thus reducing an alternative or complementary source of revenue to the less than 221kW fleet segments targeting sole.

9.2.2. Social and economic interactions

There are many economic sectors and social activities that benefit from the sole fishery. One of these sectors is tourism, where interaction with other economic sectors, including fisheries, have been identified as requiring integrated management. An example of this is the area of Devon and Cornwall where there is an important economic component of tourism, outside the fisheries sector, but directly influenced by it.:-

"a more progressive approach to coastal tourism would require that not only local authorities and private entrepreneurs should be the key actors within an effective partnership, but also environmental bodies, representatives of the productive sectors related to the sea (fishing for example), experts and actors in the cultural sectors, and the scientific community with an interest in sea-related activities" *The impact of tourism in coastal areas: regional development aspects. IP/B/REGI/IC/2006-166-Lot 01-C03-SC01 15/04/2008 PE 397.260*

Other economic and social activities interacting with the sole fishery in the 7e area are sea farming on the shore, new fish markets (e.g. the one built in Brixham) and

real estate and commercial developments in port areas. Social activity is also influenced by the sole fishery, as there are sailing and recreational fishing developing on the same or close by ports and the industry related to the fishery is also trying to develop labour opportunity for students of local schools.

There are at least two developments of social capital related directly or indirectly to the sole fishery considered. This type of developments are important when considering the impact of a multi-annual management plan, as they can influence the compliance with the plan and also provide additional instruments for the management of the fishery.

The first development is the 50 % project, an initiative of the industry that has been taken upon by research and management organization such as Cefas and Defra in the UK. It has already been considered by the STECF and is now under negotiation with the European Commission. STECF provided some guidance for the conduct of a study in the Spring Plenary 2010. If the study were approved in its current form it would consist of a scheme that would allow a group of vessels to profit from additional quota in exchange of participating in a study on how to reduce bycatch associated to sole. The fishing industry considers that this cooperation would benefit the scientific community, the management and also the longer term interests of the fishermen, through a better knowledge of the resource, a potential improvement is fishing techniques [through a lower environmental impact] and a development in the degree and scope of the communication between stakeholders.

Another scheme that implies the development of social capital is the Mid channel potting agreement in 7e. In this case, the initiative has been going on for thirty years and it is transnational, as it involves the fishing sector of the UK (pots and trawlers), France (trawlers) and Belgium (trawlers). The scheme sets two different spatial arrangements, with fixed areas allocated to pots and corridors for trawling that alternate over time. Additional corridors allow for the traffic separation scheme, managed under the UNCLOS. The mid channel potting agreement is fully managed by the industry. It coordinates the management of the area that is shared by fisheries of different target species and countries.

9.3. Conclusions to economic aspects

There are a variety of different types of regulation in place, including TAC regulations, effort restrictions (both on days at sea and number of vessels) and area restrictions. This complex of regulation limits the scope for alternative strategies to face potential lower fishing opportunities for sole, as for example TAC reductions or area closures.

The lack of flexibility is not only due to regulation but is also related to the clear separation of fishing possibilities between segments, due to technological characteristics, target species availability and allowed areas. The case of English beam trawlers below and over 221kW is a good example. This situation lowers social conflict but it also means more limited alternatives for fishing patterns when negative shocks appear.

The multi-annual plan has social and economic effects [mainly] by restricting the range of fishing patterns from which companies can choose in order to attain the profits they need for subsistence. This reduced flexibility/room for manoeuvre /

increases the potential effect of negative shocks thus making long term investment more risky and increasing the doubts on the long term continuity of the sector. The social perception of the fishery therefore deteriorates, and this has social implications as it affects for example the way local population sees fisheries as a job opportunity.

In order to widen the options for survival of the industry there are certain initiatives to increase revenues through improving the value of sole and other species in the market, as the initiation of the process for MSC certification. Other ways to reach higher longer term value for the fishery are the improvement of stock productivity through less. Participatory management is also a potential as it make better use of existing social capital and increase the array of management option available.

The three issues above are interrelated, as better habitat is valued by certification and both habitat and certification are valued by the authorities and leave the industry in a better position to negotiate and bring forward proposals for management, thus improving the social and economic impact of the multi annual management plan.

10. COST EFFECTIVENESS OF CONTROL AND ENFORCEMENT

In November 2008 the UK implemented a single area license scheme to eliminate opportunity of area misreporting of sole catches between division VIIe and adjacent fishing areas. This measure appears to be highly effective in eliminating area misreporting, with relatively small additional administrative costs. The effect has resulted in the 2010 assessment indicating a significant decline in F in 2009 to levels of the long term management target. Because this regulation has been implemented only well after the implementation of the management plan improvements in stock status have been slower than predicted by the original management plan evaluation.

11. CONCLUSIONS TO THE IMPACT ASSESSMENT

In the absence of reference points it is difficult to evaluate the yields in the context of appropriate risks for specific exploitation rates of this stock (see section 8 above). If F is maintained at or below the current target and the historic levels of recruitment continue the stock is expected to recover further and to reach a biomass above Bloss in the short term. The risks decline over time with higher risks initially until biomass rises. The duration of the high risk period depends on realised recruitment and the realised exploitation rate. Fs above the current target are associated with higher risks and may also give lower yields (depending on currently poorly defined stock dynamics)

Simulations suggest very little reduction in the long term catch of sole with Fs between 0.27 and 0.2 however, with reduced Fs interactions with other fisheries will reduce income in the short term and may reduce income in the longer term particularly if available effort is reduced or incompatible targets (among other species) lead to discards of sole.

11.1. Comparison of Options

Currently with the SSB close to a recent low and still below the historic Bloss all strategies have short term risks due to natural variability in recruitment

Constant TAC targets give either lower yield for the same risks as F strategies or higher risks for the similar yields.

Risks rise disproportionately if target Fs are at 0.3 and greater, and attain high levels under certain biological assumptions. In some situations of this type long term risks are higher than short term risks indicating that these may be inappropriate strategies for exploitation if the aim is to lower risk.

Fs between 0.2 and 0.27 give similar yields, though very slightly higher yields are found between F-0.25-0.27, suggesting that this Fmsy might be closer to 0.27 than 0.2.

Constraint to interannual variability in TAC generally had little effect on risks, but did suggest that Fs slightly below Fmsy were required under TAC constraint, because catches decline faster with varying F above F=0.27 than below 0.27.

Banking and then paying back up to 10% of the TAC has no important impact on long term risks. However, it was difficult to predict how the fishery would use this option so the results may not be entirely realistic.

Increased measurement error is associated with increasing risk and to a lesser degree declining yields.

In the absence of any specific risk avoidance criteria it is not possible to give specific target advice in absolute terms, but Fs in the range 0.2 to 0.27 provide comparatively high yield of sole and relatively low risk.

11.2. Effectiveness: best placed to achieve the objectives (select appropriately just to relate to the objectives given above)

The F target has already been reached

SSB is still lower than desirable

There is a balance of achievement between achievement of catch and SSB targets. SSB will rise more quickly at lower target Fs but lower catches are associated with greater economic difficulties in short term. If F is reduced below F=0.2 the reductions in catch will occur into the long term. If F is maintained at or below 0.27 risks fall in the longer term.

11.3. Efficiency: cost-effectiveness

No models are available to examine MEY targets, in the absence of information to maximise economic yield, maximising catch in the long term is the best strategy. However consideration needs to be given to the fact that this is a multi-species fishery with only 10-20% of revenue from the sole stock. Reductions in effort that reduce other catches in the long term will have a detrimental economic effect.

11.4. Consistency: limiting trade-offs across the economic, social and environmental domains

The only projection model data available is yield data which maximizes landings and is thought to be close to or above maximum economic yield. No social studies are available though some indicators are provided. As a first step it is important to maintain biological sustainability.

12. FORWARD LOOK TO EVALUATION

Economic considerations

Data is available, there is a need to develop a model to use his data. It would be particularly useful to include social aspects in modeling (see Section 9 above)

It is important to collect economic data by stock and area foe Belgian and French fleet segments that participate in these fisheries.

Biological considerations

There is a need to develop plausible precautionary limit reference points or risk criteria.

APPENDIX A FRAMEWORK FOR IMPACT ASSESSMENTS REPORT

The following layout describes the minimum aspects to be considered in preparing an Impact Assessment. In addition the meeting should consult the Table in Appendix I which details a more complete list of relevant questions for impact assessments, where appropriate additional aspects should be added.

1. PROBLEM STATEMENT

The Commission should provide scope and limits of problem to be addressed

Why there is a need to react and where appropriate link this to background studies or information.

2. DEFINE OBJECTIVES : GENERAL / SPECIFIC / OPERATIONAL

General objective: will be CFP (statement provided by the Commission)

Specific objective: what the objectives are in terms of changes and expectations of outcomes with timescales (for example achieving exploitation target in X years)

3. IDENTIFY TACTICAL METHODS

Describe the operational objectives (which may be option dependent)

Effort changes / or Capacity / or TACs with interannual stability criteria.

Select the different approaches that are to be considered.

These should be predefined by Commission and limited to a specified range confirmed at the scoping meeting.

4. OVERRIDING CONSIDERATIONS OF THE OPTIONS

Identify if there are significant parts of the any options that are unlikely contribute to the overall objectives

Identify if in the opinion of the evaluators the options are likely to be able to deliver the objectives of the plan.

5. ENVIRONMENTAL EFFECTS OF THE OPTIONS

5.1. Evaluation of the effects of the multi-annual plan options on the fishery

Show what is expected to be the resulting impact on landings and the fleet of any of the following aspects that are affected by the plan options:-

• Catch and effort limitations – either through TAC or effort management expected to result from the different options.

• Technical measures – eg. Closed areas, gear restrictions, etc. that are included in the options.

• Control and enforcement measures proposed – eg. Entry and exit rules, allocation rights, etc. and any exemptions,

• Capacity management measures that are included in the options,

What is the expected fishery response to the different options? The response strategies of the fleets include possible shifts to other stocks or species, to other gears or métiers, changes in discard and slippage and other behavioural issues.

5.2. Evaluation of the effects of the options on the stock

This section should be adapted to any particular plan and stock.

a) Evaluating the stock response to the changes in the fisheries resulting from the plan - will the options deliver their own internal objectives with respect to the stock?

b) Evaluating whether the values of target and other reference points referred to in the plan are consistent with current knowledge and the objective of achieving MSY by 2015.

• Are the reference points in the plan appropriate given the current information on stock status and dynamics?

• Are the options likely to achieve F_{MSY} by 2015? If not, why? (see note 1)

• Are the options likely to be considered precautionary. If not, why? (see note 2)

• Is there a need to propose all the measures in the plan to make it capable of achieving the objectives? If so is STECF able to propose simpler options for a better plan to achieve stock – specific objectives?

5.3. Evaluation of the effects of the multi-annual plan on the ecosystem.

• What impacts of the different options plan on the ecosystem can be identified? Ecosystem impacts might include changes in discarding practices, by-catch rates, and catch of non-target species, habitat degradation, etc.

• What will be the effect on agreed indicators or descriptors that are directly (and where possible indirectly) affected by the options.

6. SOCIAL AND ECONOMIC EFFECTS OF THE PLAN

6.1. Data and Calculation of Indicators

• If there is no explicit socio-economic objectives defined by the multi-annual plan the options should be measured against the general socio-economic objectives as stated in the CFP.

• Will the explicit socio-economic objective defined by the multi-annual plan be met by the different options.

• The social and economic state of the fleets exploiting the stock or stocks concerned can be assessed using appropriate indicators, i.e. those proposed in the plan or those given below which include those proposed by STECF in the April 2009 plenary report.

Yearly economic indicators

- *Value of landings* ~ revenue from sale of fish.

- *Market price* ~ ex-vessel price and where possible price along the chain.

- *Gross Cash flow* ~ income minus all operational costs (excluding capital costs).

- *Break even revenue* ~ long term break even revenue. The income (revenue) level at which economic profit is zero.

- *Gross Profit* ~ income minus all costs, including capital costs.

- *Gross Value added* ~ contribution to gross national product (GNP). Income minus all expenses except capital costs and crew cost.

- *Fleet size and composition and value*

- *Return to be shared* - (share of owner (incl. vessel) and crew after paying the running costs) Turnover - landings costs – fuel costs – food costs – bait costs – ice costs (can be calculated from DCF data)

It is important to identify which indicators are appropriate for the specific cases being assessed as it is unlikely that all of these will be available or appropriate in all cases. The scoping meeting should identify specify economic criteria to allow a comparison between different plans. Once economic criteria for evaluation are selected, the appropriate methodology and data should be specified. The scoping meeting should identify additional data and models that might be required to evaluate the effects of the plan.

Longer term economic indicators over the period of the impact assessment should be obtained from cost benefit analysis.

- Net present value

Social indicators

- Employment (and in other fishery sectors)

- Salary ~ if data is available (in the future)to compare with other sectors (job market)

7. COST EFFECTIVENESS OF CONTROL AND ENFORCEMENT

Do the different options have important differences in implementation costs against there effectiveness in delivering the objectives of the plan. (for example is one option able to deliver better conservation measures than another at comparable costs, or do both options has similar conservation properties with differing costs). There is currently no general methodology to provide a quantitative cost/benefit analysis of control and enforcement, however, if there are important aspects to be considered these should be described qualitatively.

8. CONCLUSIONS TO THE IMPACT ASSESSMENT

8.1. Comparison of Options

• based on agreed criteria and draw-up a short-list of options that satisfy the Commissions Objectives for further discussion (Always include option « No Change»)

• Provide a summary table of options

•Screen possible options to see which can best meet the objectives using the agreed the criteria from the scoping meeting to be used to compare the options.

8.2. Effectiveness: best placed to achieve the objectives (select appropriately just to relate to the objectives given above)

• What would be the short and long term impacts for the stock(s) and fleets and linked economic sectors affected by the different options. Will the tactical objectives of the plan be achieved?

• What would be the short and long term impacts of the multi-annual plan on the environment and the ecosystem, for example by-catch, discards, non-target species?

• Are there any likely side effects that might result from the plan? (for example, changes in behaviour that affect other fisheries, or environmental consequences, changes in the market).

• Has the implementation been affected by external factors such as global change, ecosystems effects, or other fisheries?

8.3. Efficiency: cost-effectiveness

• What will be the impact of this plan in terms of for example employment, gross revenue of the fleet?

• Will there be any effects on the broader industry (processing, transporting, auxiliary)?

• What are the expected economic benefit/loss during the period of implementation?

8.4. Consistency: limiting trade-offs across the economic, social and environmental domains

• Are there important tradeoffs between the three main objectives of the CFP (economic, social and environment) that are importantly different amongst the options.

• Are is there any overriding major imbalances among the three main objectives of sustainable economic, social and environmental aspects.

8.5. Forward look to Evaluation

• Define a set of appropriate indicators to measure implementation, compliance, effectiveness, costs and other impacts.

• Plan for future evaluation or review of the policy initiative (when, by whom, what, how?)

Notes:-

1) Achieving targets (F_{msy})– means with 50% probability of achieving this by specified time

2) Precautionary approach criteria in agreement with ICES criteria (95% SSB>Blim) (95% F<Flim)

ANNEX B WESTERN CHANNEL SOLE SIMULATIONSD UNDER DIFFERENT CONDITIONS

Sven Kupschus CEFAS lowestoft

Stock Characteristics

Stock simulations were performed within the FLR framework. The starting point of the simulations was the latest assessment performed by ICES (WGCSE 2010). Although the assessment methodology has changed recently previous assessments did not indicate that generally the stock was in a different conditions, but there were some issues with regards to retrospective patterns. For the purpose of these simulations a selectivity pattern taken over a 10 year period was used (V_SelPat = "Smoothed_10y") to minimise some of the effects of the uncertainty with respect to F –at-age in the most recent year.

Stock weight and catch weights were independently resampled with replacement from stock and catch weights over the period 1988 – 2007, with values for all ages within a year remaining grouped. Natural mortality and percent maturity-at-age were constants in the simulations, as in the current ICES assessment methodology. Stock numbers at the beginning of 2010 were taken to be those estimated from the assessment, with expected landings of 618t in 2010. Simulations therefore start diverging in 2011 when new management measures would first take effect if implemented at the December council.

Recruitment dynamics

Estimating realistic future recruitment proved to be most difficult, because there is little obvious information as to any potential causes in recruitment variability. No clear stock recruit relationship exists, but a statistical segmented regression can be fit to the data suggesting impaired recruitment at around 4000t. ICES bases its advice on historic Bloss around 2800t but even recent low stock levels around 2280t do not imply impairment to recruitment though these values are very recent 2008. Equilibrium estimates of the relative states of NS and WC sole stocks indicated an equivalent inflection point for WC sole based on the steepness value of NS suggested the modal inflection of the SR relationship would be near 1100t.

In addition to these difficulties it is notoriously difficult to estimate the variation in recruitment accurately. The delta method usually used employs a normal distribution based on the variance estimate from the observed log-normal recruitment. Recruitment timeseries thus created tend to be less over dispersed than observed recruitment estimates thus providing more apparent stability to the stock than is warranted thus underestimating risk. Therefore in these simulations recruitment is randomly resampled from observed recruitment. To include effects of SSB on recruitment it is rescaled to the ratio of SSB current / V_Btrig when SSB < V_Btrig, where V_Btrig is the inflection point (The naming of V_Btrig is unfortunate, because ICES now uses this name as a precautionary reference point when some management action is needed. However this value was originally meant to reflect the point at which future recruitment becomes impaired consistent with its use here).

Autocorrelation is equally difficult to simulate from observed recruitment values, particularly when as here the timeseries is too short to evaluate the periodicity of this

autocorrelation. Instead recruitment values were split into what appears to be different levels of recruitment, high (1974-1990), low (1991-2008). 1969-1973 recruitment values were, because the period is too short to effectively work with and the recruitment estimates are much more uncertain from the assessment. These values were however included in all (1969-2007) which is to simulate random variation in recruitment. Autocorrelated recruitment resamples from the period of high and low recruitment dependent on the probability in a given year of changing from one recruitment state to the other (V_penviro) with the initial state of recruitment (V_rstart 0=low, 1=high). Four recruitment types (V_Rtype) are thus implemented, low, high, autocorrelated and all. The effect of SSB on the autocorrelated recruitment is implemented completely independently despite the fact that this potentially leads to inconsistencies. For example if V_Btrig is set to 4000t and recruitment is autocorrelated future recruitment would be underestimated, because the lower recruitment associated with the autocorrelation would be further scaled back if SSB were below 4000t. In other words the cause of the decline in recruitment would be double counted. Consequently not all permutations of the V_Rtype and V_Btrig make sense and scenarios must be chosen carefully so that they make sense in terms of the stock dynamics and the knowledge of what causes the fluctuation in recruitment.

Assessment uncertainty:

The precision of the stock assessment is generally estimated by the respective methodology. XSA provides information in terms of the internal and external standard errors, but generally with most methods these tend to underestimate the true confidence interval as suggested by retrospective analyses. This is true more generally of other methods which are not based on log-likelihood assumptions, so there seems little point in resampling incorrect error distributions. In terms of forecasting catches it is likely that there will be some implementation bias causing a difference in the actual rate of exploitation compared to that implied by the management plan. Strictly speaking these components of variation are independent, but they have the same effect on the fishing mortality rate. Since both are assumed to be normally distributed they have been implemented as a single effect on the TAC (V_lnstdev: an normal error term on future F). The setting of this parameter is arbitrary in the sense there is little or no information available, which is why a range is tested in these simulations.

The risk to the stock associated with these settings is conditional so that although at high values of variance the stock may be more likely to collapse, one cannot say whether a management strategy is risky in general just because under extreme values of error and bias assumption the stock may be likely to collapse, because such values may be unrealistic in the first place.

The western channel sole assessment, and in fact many of the flatfish assessments have shown periodic retrospective bias. Although the latest assessment has chosen setting that minimise the likelihood of bias, there is no guarantee that such bias will not return. In fact the old assessment methodology now shows little retrospective bias. Nevertheless it seemed important to be able to simulate such effects. V_pTACbias describes the likelihood of the residual from one year having the same direction as the residual of the previous year. It is implemented by splitting the V_lnstdev sampling into positive and negative residuals and then sampling from these subpopulations. V_Tstart describes the initial state of the retrospective bias

(0=persistently overestimate F; 1=persistently underestimate). In WC sole only the earlier has been observed which tends to protect stocks managed by F targets, however it is unclear whether this is a permanent characteristic of the assessment or not. All simulations using V_pTACbias have allowed for both types of retrospective bias, so that the risk to the stock may be over-emphasised based on what we know regarding this stock. The situation of a permanent bias in one direction could be implemented either through setting V_pTACbias, but this tends not to produce expected error distributions under these circumstances, why an additional permanent bias component can be added using (V_lnmean) but this has not been implemented here due to the uncertainty regarding future assessment outcome.

Simulations carried out

A total of 74 simulation runs have been carried out to examine the influence of various factors. The detailed parameterisation of the simulation runs is given in Table B1. The

Two management strategies, constant F and constant TAC, have been evaluated at different levels of exploitation under these various biological and assessment assumptions which allows comparisons of the conditional yields and risk from each scenario. Additional management measures that have been investigated are constraint in the variation of TAC and TAC banking, although different levels of these have not been investigated.

Risks are define at three points

- Short term the risk of being below in just 2015 (a single year)
- Medium term the risk of being below Biomass point at least once in 2016-2025 (10 years)
- Long term the risk of being below Biomass point at least once in 2026-2035 (10 years)

A the short term risk is defined for a single year the risk values for short term do not translate directly to the medium and longer term values. Comparing risk in the medium and longer term indicates of a stategy is generally expected to improve or not into the future. This is important as the stock is currently recovering from a low SSB. The yield and risk results are given in Table B2

The different runs are illustrated in Figures. Table B3 sjowes which type of Figure are available for each run.

Table B1 Setting of the Variable Parameters used by Run

Simulation Run			Biological Hypothesis		Assessment uncertainty				Management measures					
	V_Rtype	V_penviro	V_rstart	B inflec	V_SelPat	V_lnstdev	V_pTACbias	V_MStrat	V_Ftarg	V_TACconstr	V_maxTAC	V_TACbank	V_bankP	V_lbank
Run1	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.1	Inf	618	0	5	0.95
Run2	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.15	Inf	618	0	5	0.95
Run3	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.2	Inf	618	0	5	0.95
Run4	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.25	Inf	618	0	5	0.95
Run5	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0	5	0.95
Run6	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.3	Inf	618	0	5	0.95
Run7	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.35	Inf	618	0	5	0.95
Run8	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	FBased	0.4	Inf	618	0	5	0.95
Run9	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	600	0	5	0.95
Run10	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	650	0	5	0.95
Run11	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	700	0	5	0.95
Run12	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	750	0	5	0.95
Run13	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	800	0	5	0.95
Run14	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	850	0	5	0.95
Run15	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	900	0	5	0.95
Run16	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	950	0	5	0.95
Run17	"autocor"	0.1	1	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	1000	0	5	0.95
Run18	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.1	Inf	618	0	5	0.95
Run19	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.15	Inf	618	0	5	0.95
Run20	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.2	Inf	618	0	5	0.95
Run21	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.25	Inf	618	0	5	0.95
Run22	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0	5	0.95
Run23	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.3	Inf	618	0	5	0.95
Run24	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.35	Inf	618	0	5	0.95
Run25	"all"	0	0	4000	SMD10y	0.1	0.2	FBased	0.4	Inf	618	0	5	0.95
Run26	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	600	0	5	0.95
Run27	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	650	0	5	0.95

Simulation Run			Biological Hypothesis		Assessment uncertainty				Management measures					
	V_Rtype	V_penviro	V_rstart	B inflec	V_SelPat	V_Instdev	V_pTACbias	V_MStrat	V_Ftarg	V_TACconstr	V_maxTAC	V_TACbank	V_bankP	V_lbank
Run28	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	700	0	5	0.95
Run29	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	750	0	5	0.95
Run30	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	800	0	5	0.95
Run31	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	850	0	5	0.95
Run32	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	900	0	5	0.95
Run33	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	950	0	5	0.95
Run34	"all"	0	0	4000	SMD10y	0.1	0.2	TACBased	-1	Inf	1000	0	5	0.95
Run35	"high"	0	0	2277	SMD10y	0.1	0.2	FBased	0.2	Inf	618	0	5	0.95
Run36	"high"	0	0	2277	SMD10y	0.1	0.2	FBased	0.25	Inf	618	0	5	0.95
Run37	"high"	0	0	2277	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0	5	0.95
Run38	"high"	0	0	2277	SMD10y	0.1	0.2	FBased	0.3	Inf	618	0	5	0.95
Run39	"low"	0	0	2277	SMD10y	0.1	0.2	FBased	0.2	Inf	618	0	5	0.95
Run40	"low"	0	0	2277	SMD10y	0.1	0.2	FBased	0.25	Inf	618	0	5	0.95
Run41	"low"	0	0	2277	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0	5	0.95
Run42	"low"	0	0	2277	SMD10y	0.1	0.2	FBased	0.3	Inf	618	0	5	0.95
Run43	"all"	0.1	0	2800	SMD10y	0.1	0.2	FBased	0.27	0.15	618	0.1	5	0.95
Run44	"autocor"	0.1	0	2800	SMD10y	0.1	0.2	FBased	0.27	0.15	618	0.1	5	0.95
Run45	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.1	Inf	618	0	5	0.95
Run46	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.15	Inf	618	0	5	0.95
Run47	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.2	Inf	618	0	5	0.95
Run48	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.25	Inf	618	0	5	0.95
Run49	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0	5	0.95
Run50	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.3	Inf	618	0	5	0.95
Run51	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.35	Inf	618	0	5	0.95
Run52	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.4	Inf	618	0	5	0.95
Run53	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	600	0	5	0.95
Run54	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	650	0	5	0.95
Run55	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	700	0	5	0.95
Run56	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	750	0	5	0.95

Simulation Run			Biological Hypothesis		Assessment uncertainty				Management measures					
	V_Rtype	V_penviro	V_rstart	B inflec	V_SelPat	V_Instdev	V_pTACbias	V_MStrat	V_Ftarg	V_TACconstr	V_maxTAC	V_TACbank	V_bankP	V_lbank
Run57	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	800	0	5	0.95
Run58	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	850	0	5	0.95
Run59	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	900	0	5	0.95
Run60	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	950	0	5	0.95
Run61	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	TACBased	-1	Inf	1000	0	5	0.95
Run62	"all"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.27	0.15	618	0.1	5	0.95
Run63	"autocor"	0.1	0	2277	SMD10y	0.1	0.2	FBased	0.27	0.15	618	0.1	5	0.95
Run64	"all"	0.1	0	2800	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0.1	5	0.95
Run65	"autocor"	0.1	0	2800	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0.1	5	0.95
Run66	"all"	0.1	0	2800	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0	5	0.95
Run67	"autocor"	0.1	0	2800	SMD10y	0.1	0.2	FBased	0.27	Inf	618	0	5	0.95
Run68	"autocor"	0.1	0	2800	SMD10y	0.1	0.5	FBased	0.27	0.15	618	0.1	5	0.95
Run69	"autocor"	0.1	0	2800	SMD10y	0.1	0.05	FBased	0.27	0.15	618	0.1	5	0.95
Run70	"all"	0.1	0	2800	SMD10y	0.15	0.2	FBased	0.27	0.15	618	0.1	5	0.95
Run71	"all"	0.1	0	2800	SMD10y	0.2	0.2	FBased	0.27	0.15	618	0.1	5	0.95
Run72	"all"	0.1	0	2800	SMD10y	0.3	0.05	FBased	0.27	0.15	618	0.1	5	0.95
Run73	"all"	0.1	0	2800	SMD10y	0.3	0.2	FBased	0.27	0.15	618	0.1	5	0.95
Run74	"all"	0.1	0	2800	SMD10y	0.3	0.5	FBased	0.27	0.15	618	0.1	5	0.95

Table B2 Run results yield (catches of WC sole) and risk of WC sole being below SSB =2278 and 2700 t. For the short term (2015), medium term 2016-2025 and long term 2026-2035

	Average Yield			Risk of SSB < 2278t			Risk of SSB < 2700t		
run No	short-term	medium-term	long-term	short-term	medium-term	long-term	short-term	medium-term	long-term
Run1	597	758	835	0	0	0	0	0	0
Run2	756	891	941	0	0	0	0	0	0
Run3	876	977	993	0	0	0	0	0	0
Run4	943	1003	1003	0	0	0	0.02	0.038	0.024
Run5	962	1013	1020	0	0	0.002	0.056	0.13	0.102
Run6	964	1024	1007	0.006	0.024	0.038	0.194	0.366	0.424
Run7	1012	1025	1013	0.088	0.298	0.312	0.37	0.77	0.8
Run8	1021	998	971	0.276	0.676	0.75	0.634	0.964	0.966
Run9	601	602	602	0	0	0	0.002	0	0
Run10	648	654	655	0	0.002	0	0.014	0.012	0
Run11	701	705	706	0.008	0.006	0.002	0.07	0.036	0.002
Run12	753	753	753	0.032	0.032	0.006	0.11	0.084	0.008
Run13	803	803	796	0.068	0.092	0.05	0.212	0.184	0.064
Run14	851	820	713	0.294	0.354	0.252	0.478	0.488	0.306
Run15	906	797	590	0.436	0.524	0.496	0.648	0.66	0.546
Run16	970	774	479	0.502	0.666	0.68	0.726	0.808	0.728
Run17	1025	674	298	0.67	0.816	0.846	0.828	0.908	0.882
Run18	442	607	770	0	0	0	0	0	0
Run19	551	670	837	0	0.002	0	0.042	0.052	0
Run20	609	652	709	0.038	0.146	0.138	0.38	0.608	0.408
Run21	640	594	502	0.36	0.834	0.932	0.842	0.982	0.984
Run22	644	560	422	0.528	0.96	0.994	0.902	0.998	1
Run23	642	512	324	0.826	0.998	1	0.982	1	1
Run24	640	447	224	0.962	1	1	1	1	1
Run25	633	398	154	0.996	1	1	1	1	1
Run26	604	589	461	0.214	0.446	0.45	0.498	0.6	0.474
Run27	656	592	313	0.404	0.702	0.7	0.688	0.788	0.73
Run28	703	548	166	0.568	0.862	0.884	0.828	0.918	0.896
Run29	763	466	83	0.724	0.936	0.966	0.886	0.962	0.968
Run30	821	387	40	0.81	0.976	0.988	0.916	0.984	0.99
Run31	879	288	9	0.91	0.994	0.998	0.984	0.996	0.998
Run32	904	226	3	0.94	0.998	0.998	0.98	0.998	1
Run33	873	163	1	0.972	1	1	0.996	1	1
Run34	770	113	0	0.982	1	1	0.998	1	1
Run35	894	1032	1093	0	0	0	0	0	0
Run36	959	1060	1104	0	0	0	0.06	0.046	0.004
Run37	984	1076	1109	0.002	0.002	0.002	0.13	0.142	0.072
Run38	1009	1084	1104	0.018	0.044	0.012	0.314	0.44	0.3
Run39	735	820	855	0	0	0	0.042	0.026	0.002
Run40	785	846	870	0.028	0.028	0.012	0.372	0.508	0.406
Run41	799	851	879	0.086	0.142	0.062	0.564	0.796	0.686

	Average Yield			Risk of SSB < 2278t			Risk of SSB < 2700t		
run No	short-term	medium-term	long-term	short-term	medium-term	long-term	short-term	medium-term	long-term
Run42	812	846	861	0.29	0.566	0.432	0.832	0.97	0.952
Run43	798	845	883	0.176	0.392	0.286	0.628	0.806	0.698
Run44	789	859	935	0.196	0.342	0.226	0.68	0.778	0.596
Run45	525	695	818	0	0	0	0	0	0
Run46	683	833	918	0	0	0	0	0	0
Run47	779	898	972	0	0	0	0.014	0.006	0
Run48	834	934	980	0.016	0.014	0.002	0.296	0.34	0.164
Run49	844	936	987	0.07	0.088	0.016	0.494	0.606	0.388
Run50	868	933	979	0.206	0.37	0.198	0.69	0.864	0.712
Run51	870	891	907	0.582	0.852	0.784	0.92	0.996	0.972
Run52	879	830	766	0.836	0.974	0.978	0.986	1	1
Run53	606	603	600	0.01	0.004	0	0.102	0.056	0
Run54	645	654	652	0.04	0.03	0.004	0.236	0.136	0.004
Run55	704	704	695	0.128	0.14	0.032	0.426	0.352	0.04
Run56	753	746	703	0.286	0.284	0.118	0.596	0.54	0.14
Run57	805	767	625	0.462	0.486	0.326	0.702	0.694	0.382
Run58	858	752	486	0.612	0.692	0.55	0.824	0.814	0.598
Run59	923	667	359	0.71	0.798	0.748	0.86	0.882	0.794
Run60	994	562	223	0.798	0.892	0.874	0.918	0.942	0.9
Run61	996	471	130	0.874	0.942	0.928	0.958	0.966	0.946
Run62	872	935	944	0.044	0.17	0.15	0.356	0.624	0.624
Run63	861	950	977	0.064	0.142	0.116	0.44	0.626	0.514
Run64	800	849	900	0.154	0.34	0.226	0.59	0.794	0.662
Run65	792	859	934	0.192	0.368	0.222	0.676	0.79	0.57
Run66	776	836	896	0.184	0.332	0.174	0.658	0.836	0.6
Run67	767	848	941	0.206	0.362	0.126	0.706	0.812	0.494
Run68	775	854	931	0.208	0.374	0.226	0.736	0.834	0.59
Run69	773	870	945	0.13	0.274	0.204	0.618	0.708	0.498
Run70	801	843	865	0.19	0.472	0.426	0.588	0.834	0.76
Run71	809	832	830	0.224	0.552	0.558	0.604	0.856	0.818
Run72	791	869	825	0.142	0.346	0.516	0.334	0.522	0.612
Run73	834	828	773	0.276	0.642	0.696	0.534	0.834	0.842
Run74	826	813	763	0.33	0.694	0.746	0.68	0.926	0.936

Table B3 Plot summaries by Run provided below

Simulation Run	PlotSummaries produced for SG-MOS 10-06b										
	1	2	3	4	5	6	7	8	9	10	11
Run1			1								
Run2			1								
Run3			1								
Run4			1								
Run5			1								
Run6			1								
Run7			1								
Run8			1								
Run9									1		
Run10									1		
Run11									1		
Run12									1		
Run13									1		
Run14									1		
Run15									1		
Run16									1		
Run17											
Run18					2						
Run19					2						
Run20					2						
Run21					2						
Run22					2						
Run23					2						
Run24					2						
Run25					2						
Run26				2							
Run27				2							
Run28				2							
Run29				2							
Run30				2							
Run31				2							
Run32				2							
Run33				2							
Run34				2							
Run35	1										
Run36	1										
Run37	1										
Run38	1										
Run39	2										
Run40	2										
Run41	2										
Run42	2										
Run43		1					1			1	2
Run44		2									
Run45			2		1			1			
Run46			2		1			1			

Simulation Run	PlotSummaries produced for SG-MOS 10-06b										
	1	2	3	4	5	6	7	8	9	10	11
Run47	3		2		1			1			
Run48	3		2		1			1			
Run49	3		2		1			1			
Run50	3		2		1			1			
Run51			2		1			1			
Run52			2		1			1			
Run53				1				2	2		
Run54				1				2	2		
Run55				1				2	2		
Run56				1				2	2		
Run57				1				2	2		
Run58				1				2	2		
Run59				1				2	2		
Run60				1				2	2		
Run61				1				2	2		
Run62		3									
Run63		4									
Run64						1					
Run65						2					
Run66						3					
Run67						4					
Run68							2				2
Run69							3				2
Run70										2	
Run71										3	
Run72											1
Run73										4	1
Run74											1

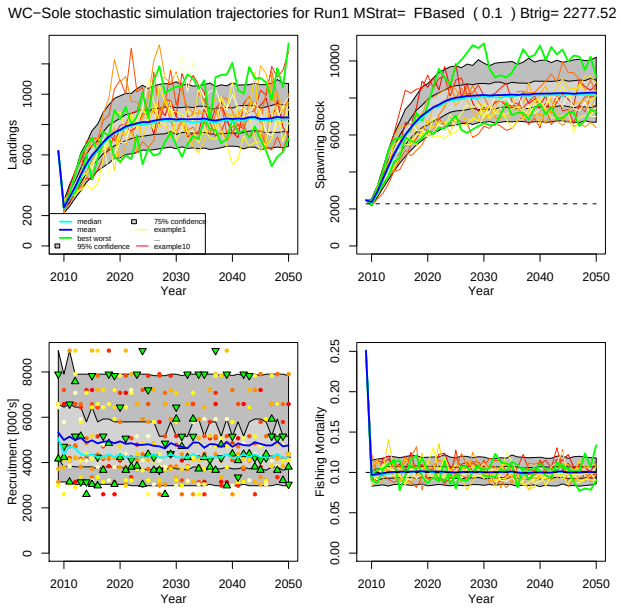

Figure1: Four plot summary results for simulations for Run1. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

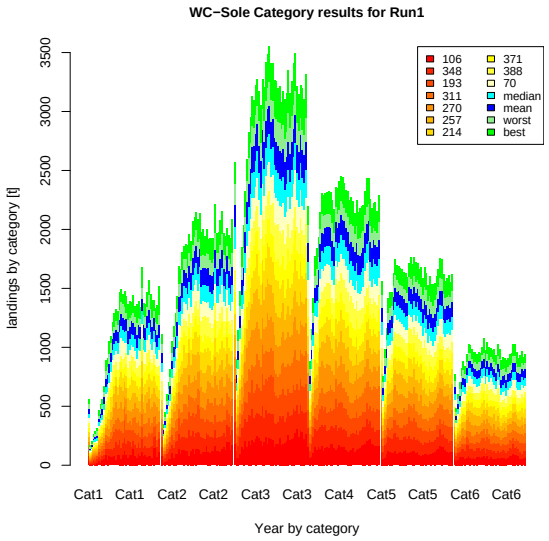

Figure2: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run1. Note that the height of the stacked bars is not equal to the average landings but a sum.

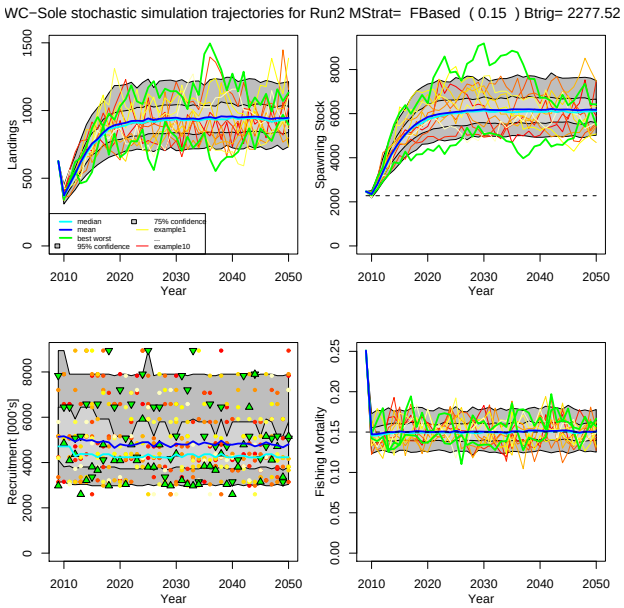

Figure3: Four plot summary results for simulations for Run2. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

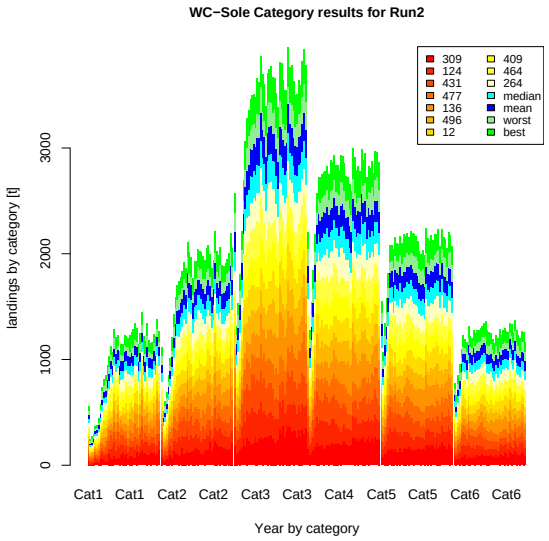

Figure4: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run2. Note that the height of the stacked bars is not equal to the average landings but a sum.

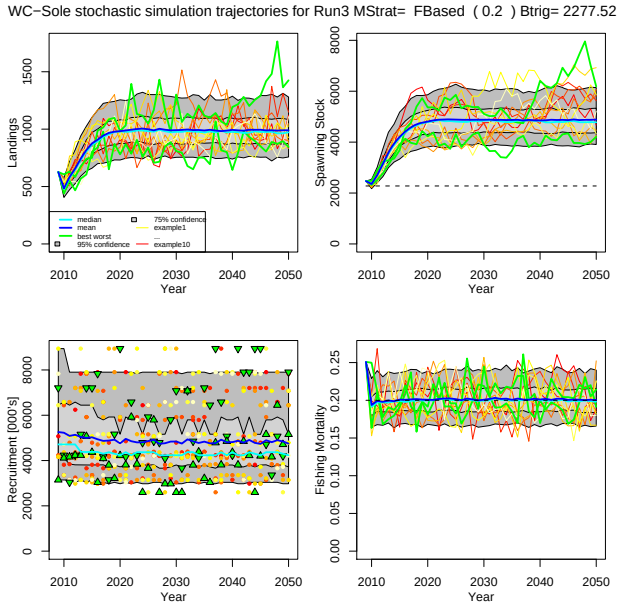

Figure5: Four plot summary results for simulations for Run3. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

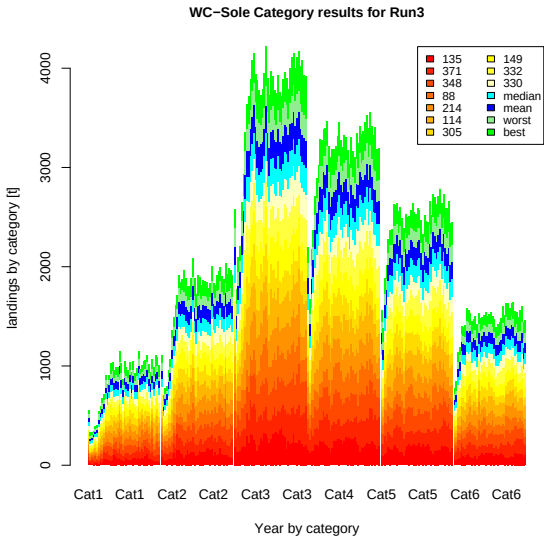

Figure6: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run3. Note that the height of the stacked bars is not equal to the average landings but a sum.

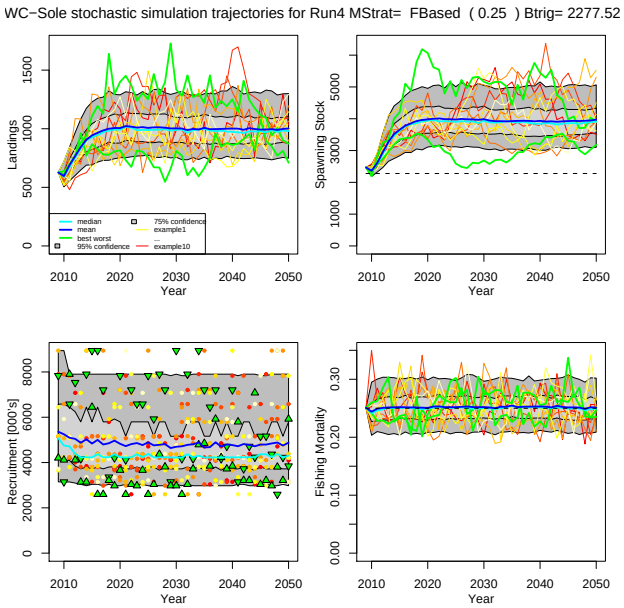

Figure7: Four plot summary results for simulations for Run4. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

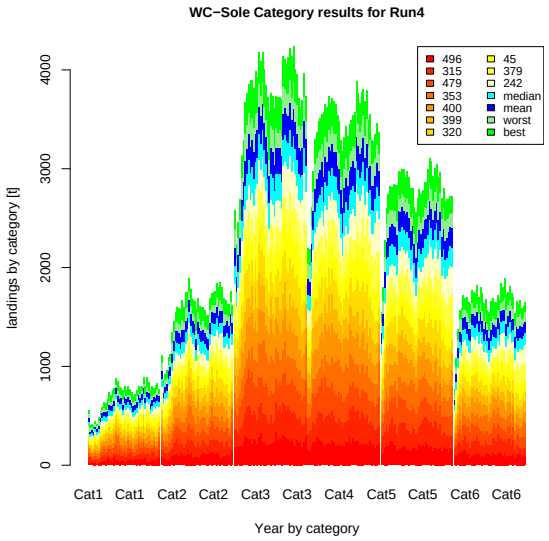

Figure8: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run4. Note that the height of the stacked bars is not equal to the average landings but a sum.

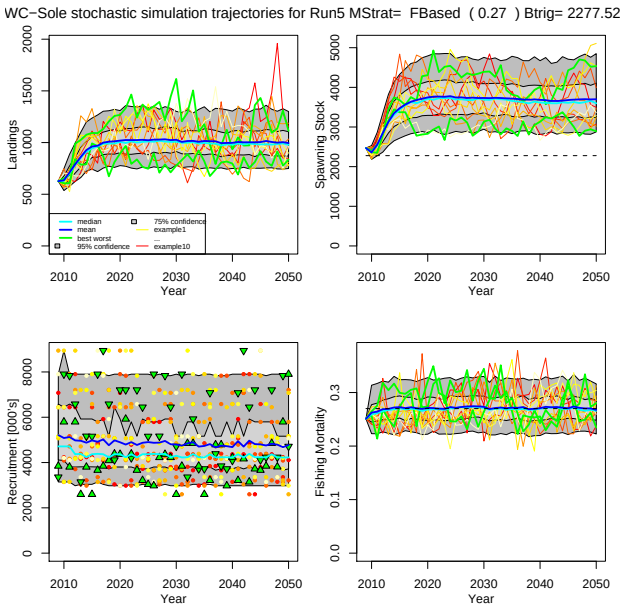

Figure9: Four plot summary results for simulations for Run5. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

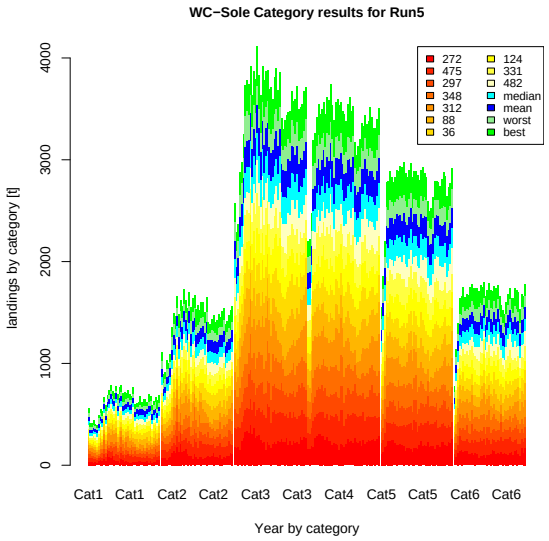

Figure10: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run5. Note that the height of the stacked bars is not equal to the average landings but a sum.

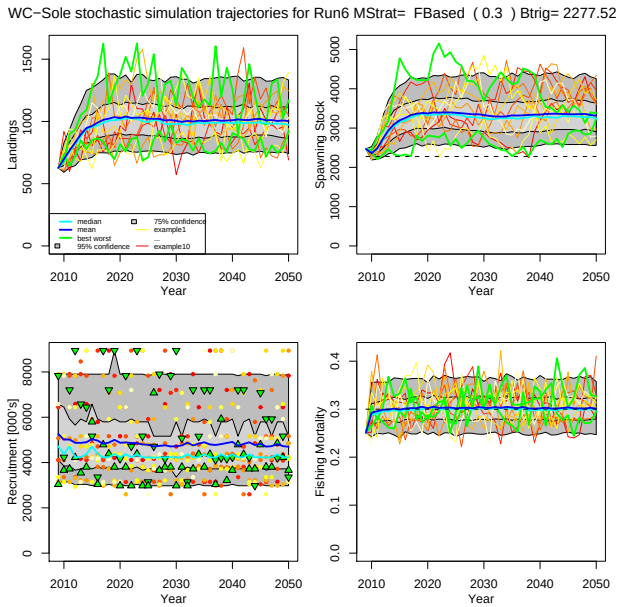

Figure11: Four plot summary results for simulations for Run6. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

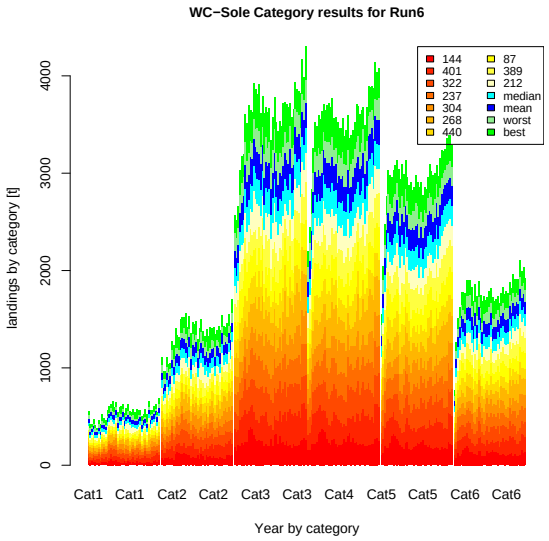

Figure12: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run6. Note that the height of the stacked bars is not equal to the average landings but a sum.

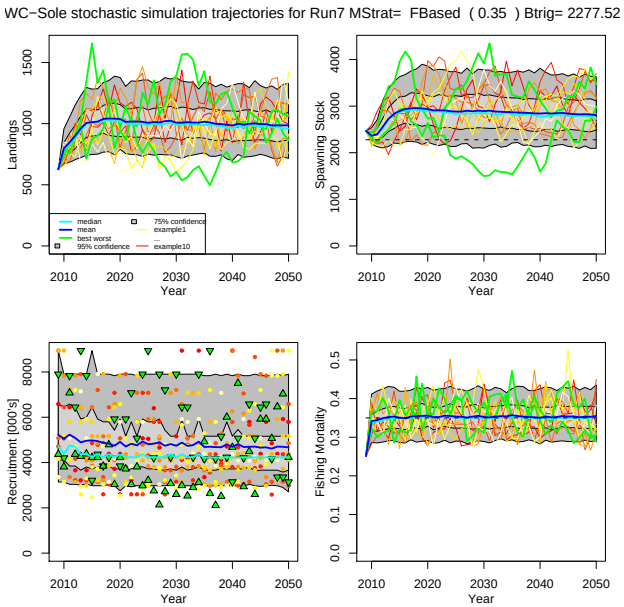

Figure13: Four plot summary results for simulations for Run7. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

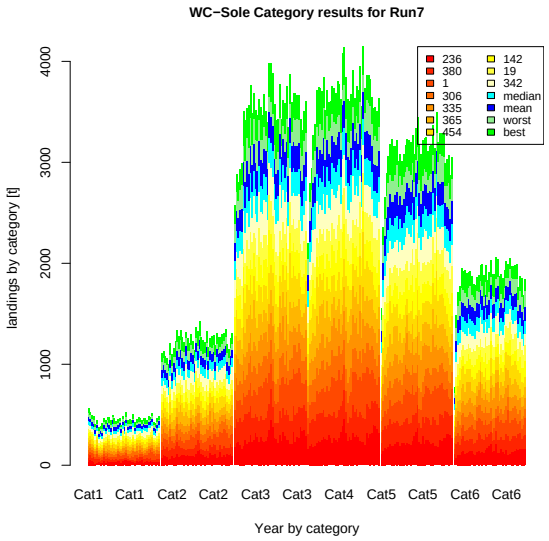

Figure14: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run7. Note that the height of the stacked bars is not equal to the average landings but a sum.

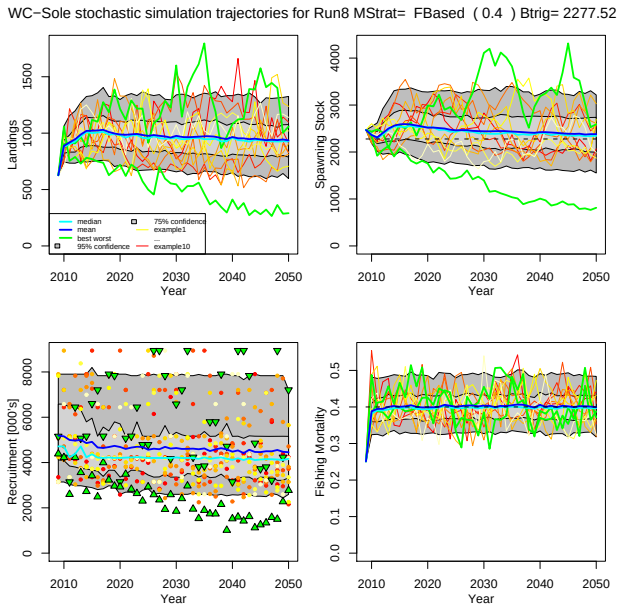

Figure15: Four plot summary results for simulations for Run8. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

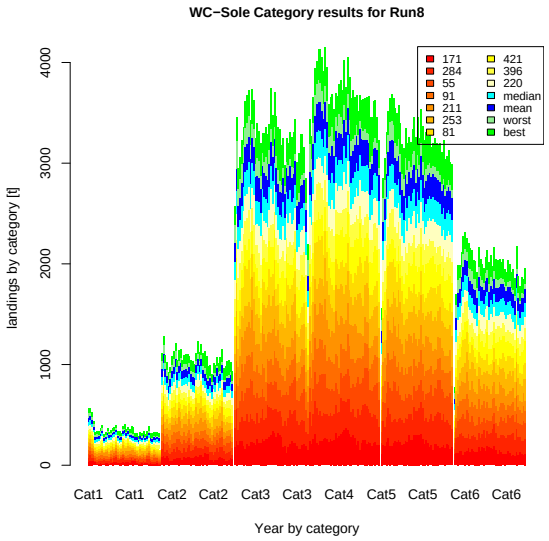

Figure16: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run8. Note that the height of the stacked bars is not equal to the average landings but a sum.

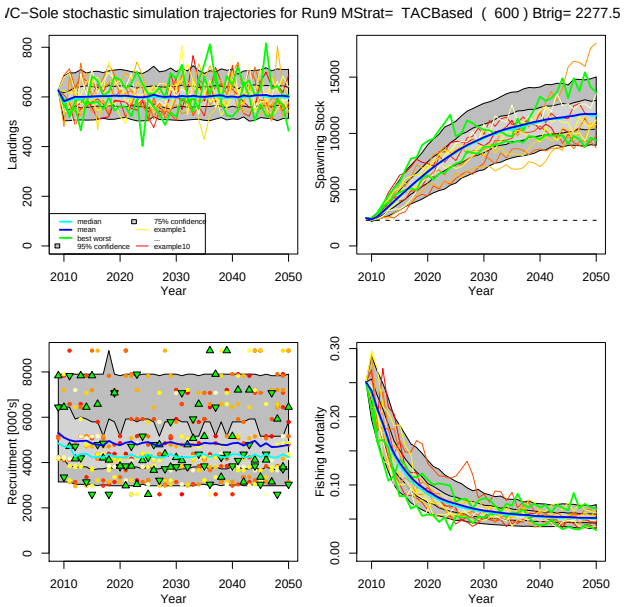

Figure17: Four plot summary results for simulations for Run9. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

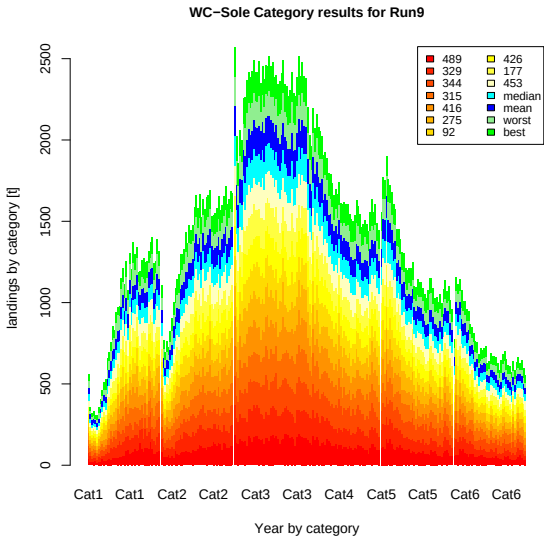

Figure18: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run9. Note that the height of the stacked bars is not equal to the average landings but a sum.

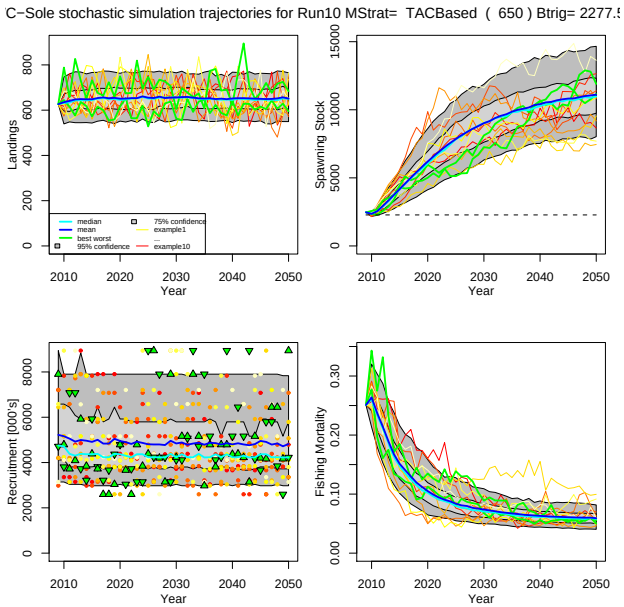

Figure19: Four plot summary results for simulations for Run10. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

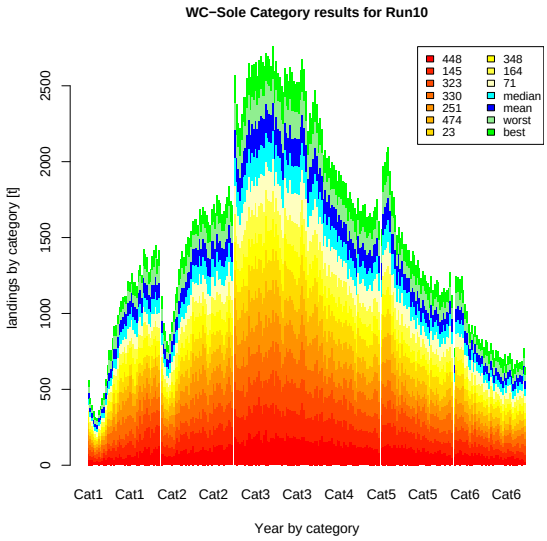

Figure20: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run10. Note that the height of the stacked bars is not equal to the average landings but a sum.

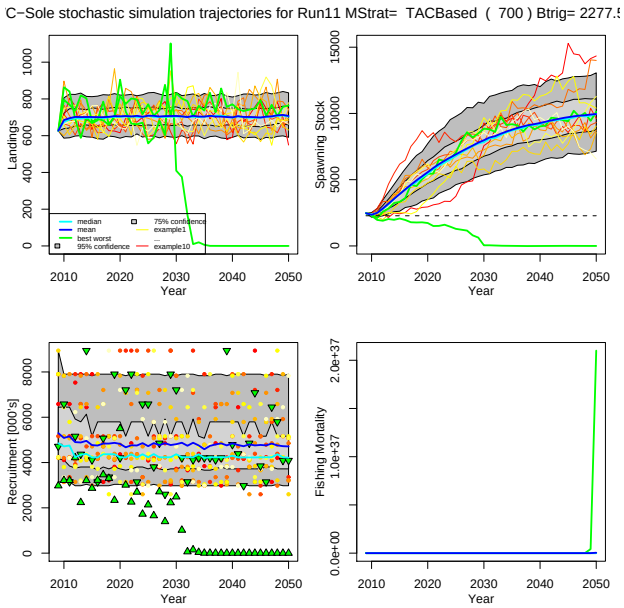

Figure21: Four plot summary results for simulations for Run11. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

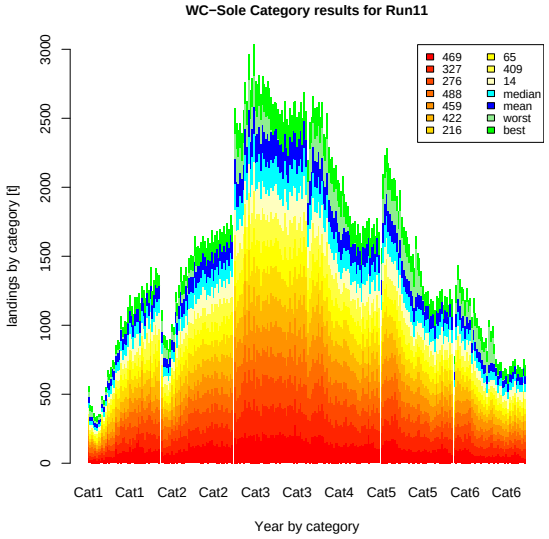

Figure22: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run11. Note that the height of the stacked bars is not equal to the average landings but a sum.

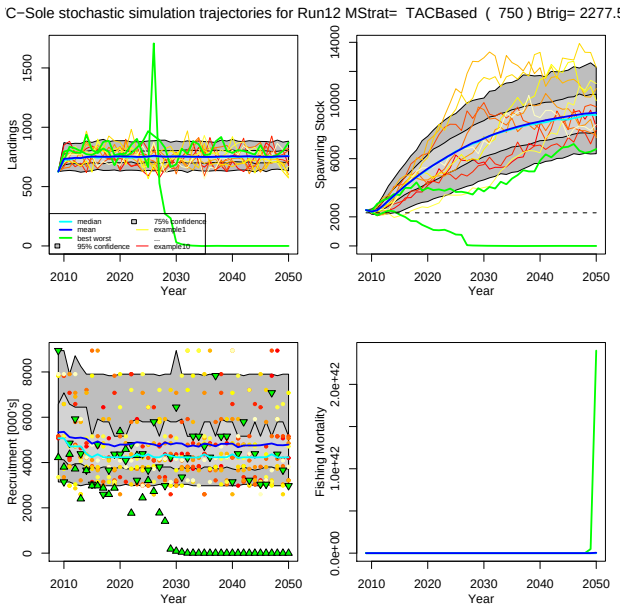

Figure23: Four plot summary results for simulations for Run12. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

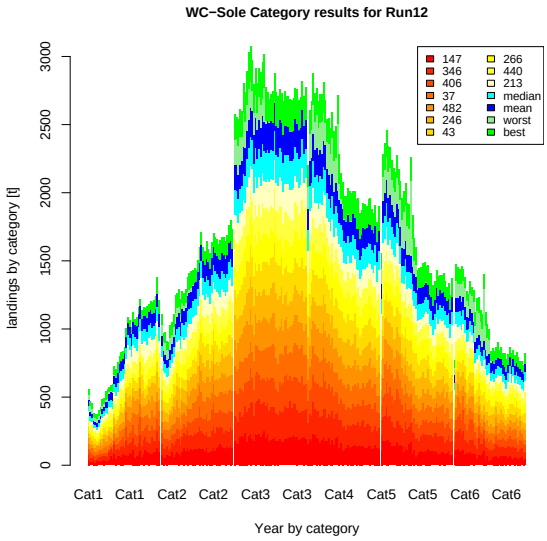

Figure24: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run12. Note that the height of the stacked bars is not equal to the average landings but a sum.

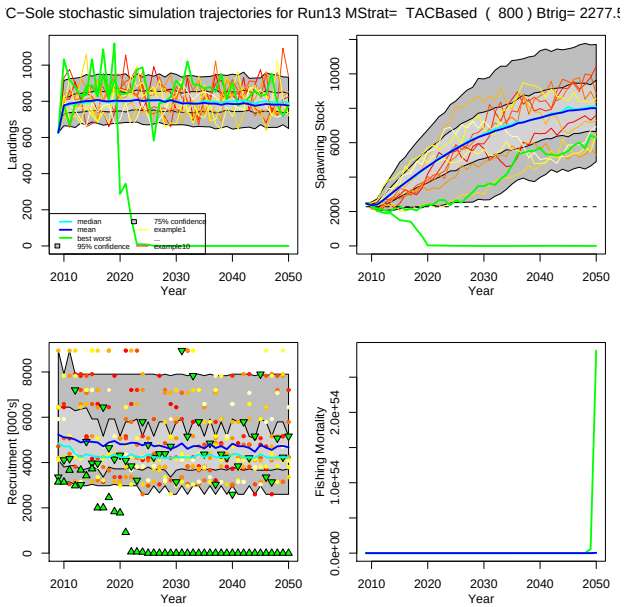

Figure25: Four plot summary results for simulations for Run13. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

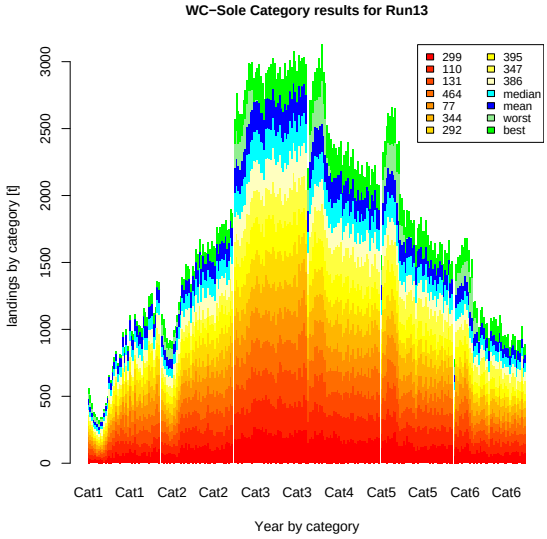

Figure26: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run13. Note that the height of the stacked bars is not equal to the average landings but a sum.

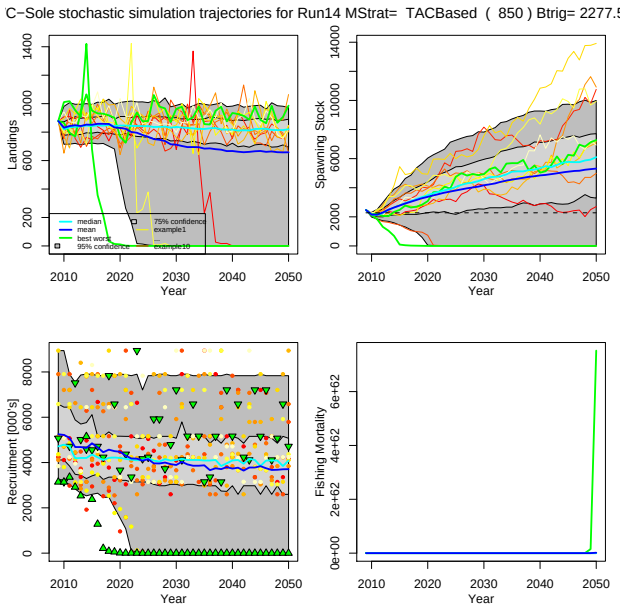

Figure27: Four plot summary results for simulations for Run14. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

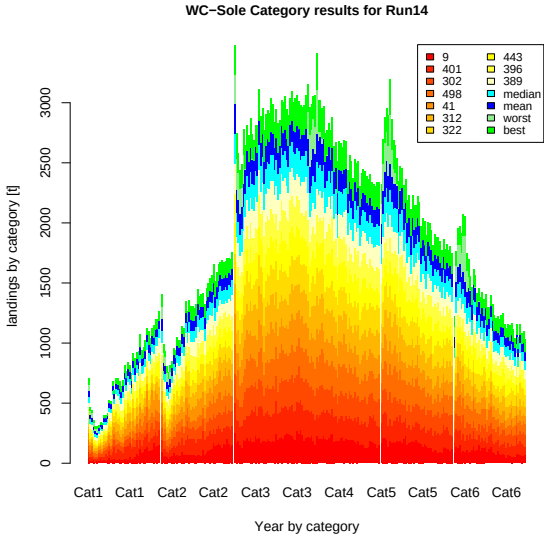

Figure28: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run14. Note that the height of the stacked bars is not equal to the average landings but a sum.

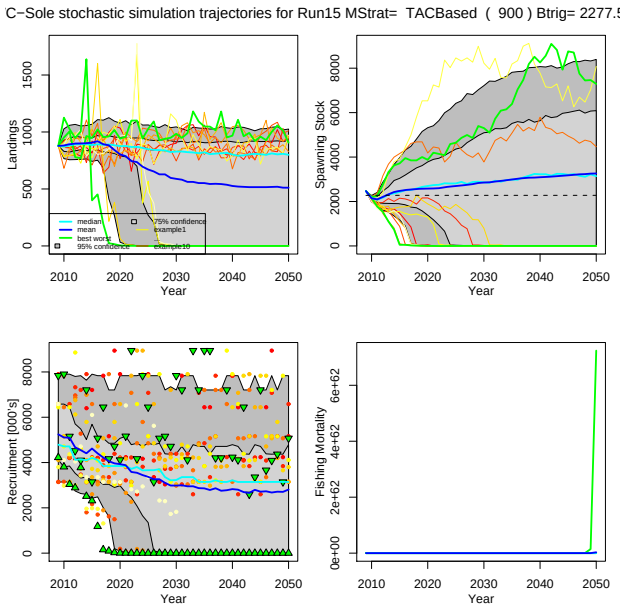

Figure29: Four plot summary results for simulations for Run15. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

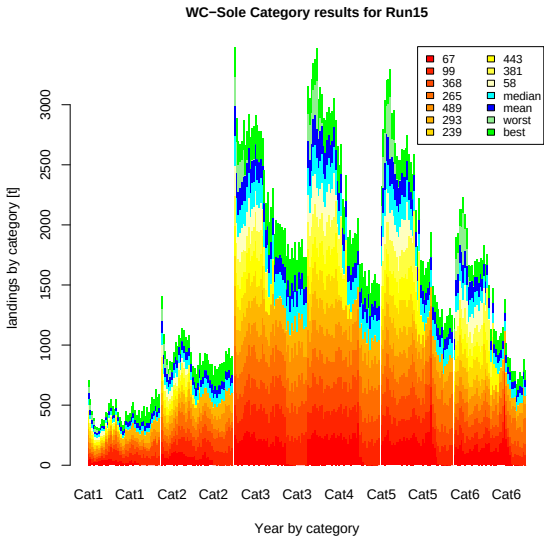

Figure30: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run15. Note that the height of the stacked bars is not equal to the average landings but a sum.

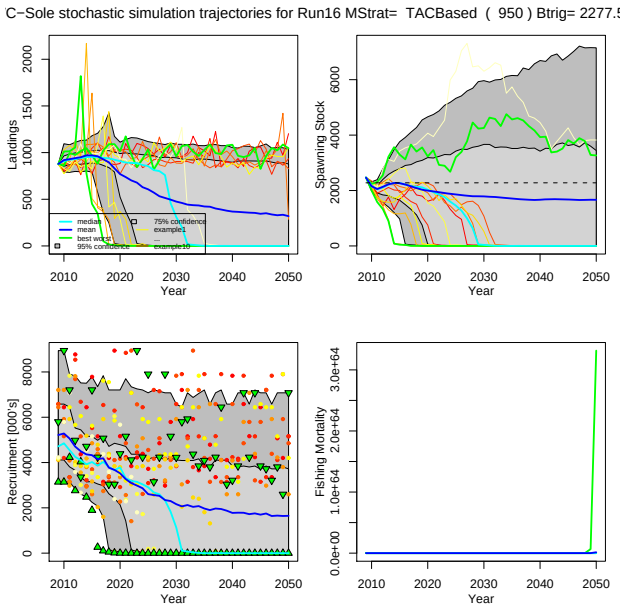

Figure31: Four plot summary results for simulations for Run16. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

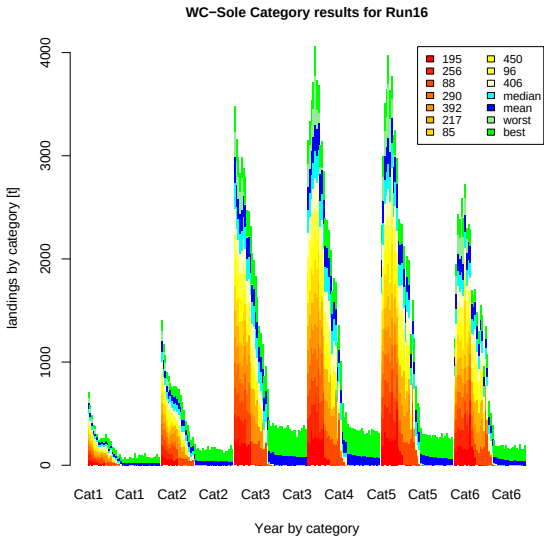

Figure32: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run16. Note that the height of the stacked bars is not equal to the average landings but a sum.

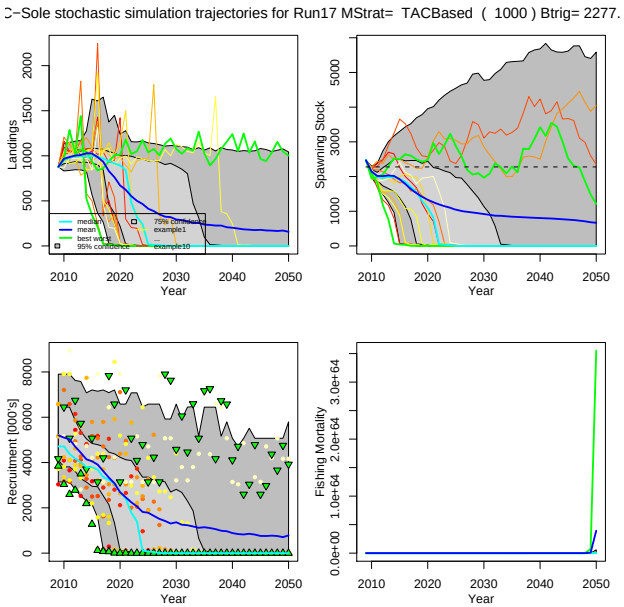

Figure33: Four plot summary results for simulations for Run17. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

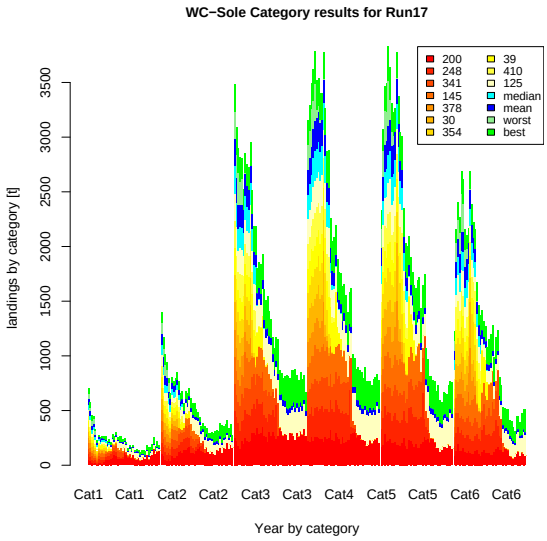

Figure34: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run17. Note that the height of the stacked bars is not equal to the average landings but a sum.

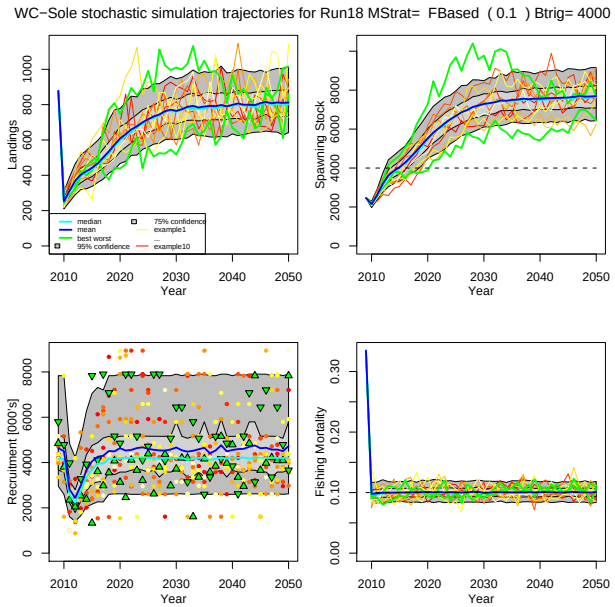

Figure35: Four plot summary results for simulations for Run18. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

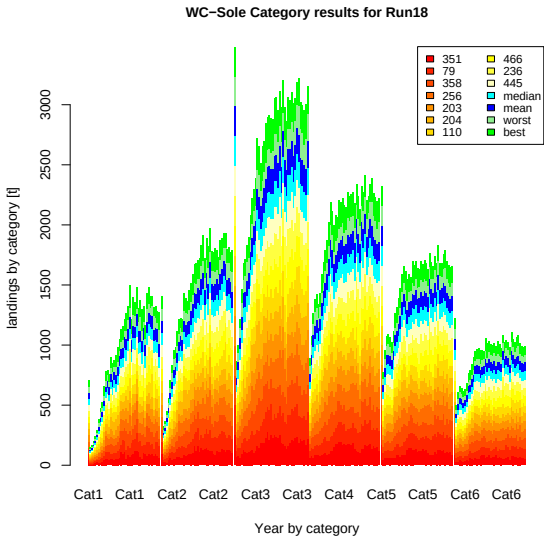

Figure36: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run18. Note that the height of the stacked bars is not equal to the average landings but a sum.

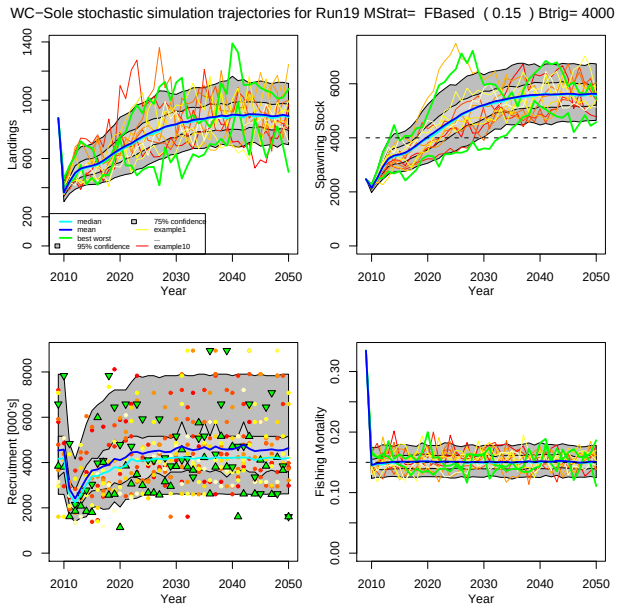

Figure37: Four plot summary results for simulations for Run19. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

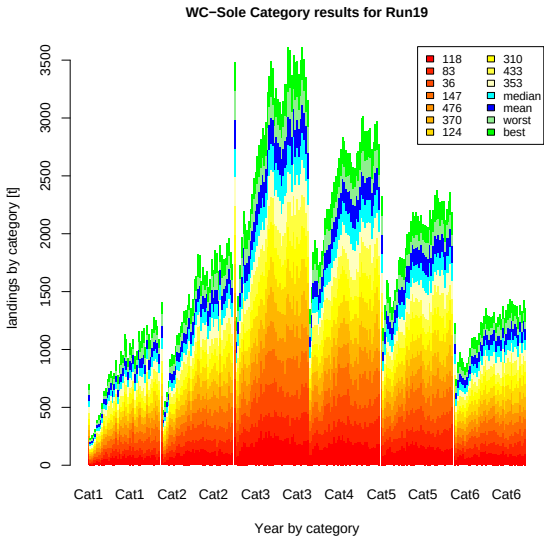

Figure38: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run19. Note that the height of the stacked bars is not equal to the average landings but a sum.

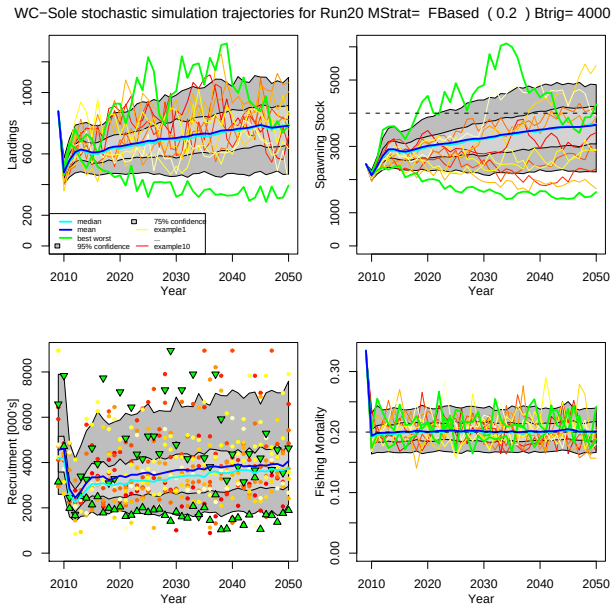

Figure39: Four plot summary results for simulations for Run20. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

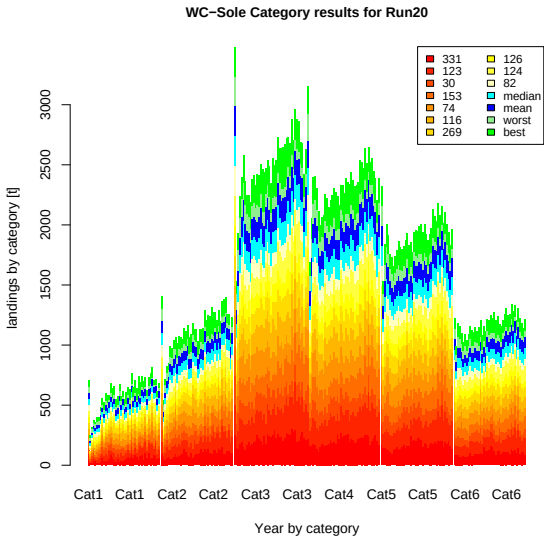

Figure40: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run20. Note that the height of the stacked bars is not equal to the average landings but a sum.

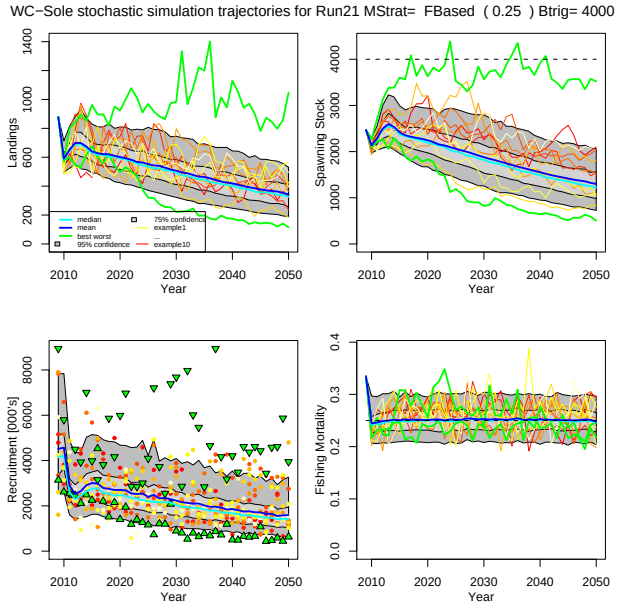

Figure41: Four plot summary results for simulations for Run21. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

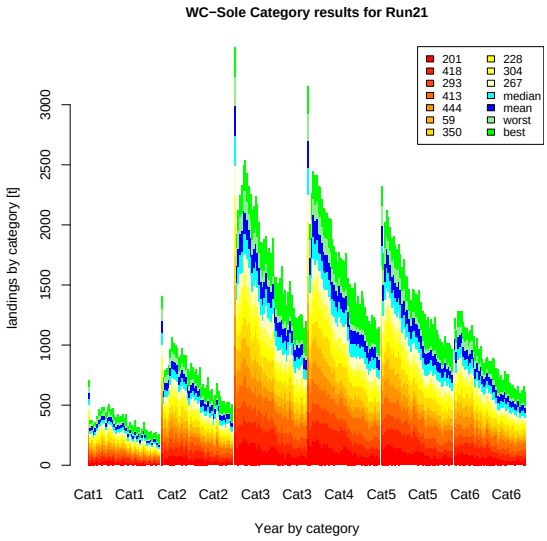

Figure42: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run21. Note that the height of the stacked bars is not equal to the average landings but a sum.

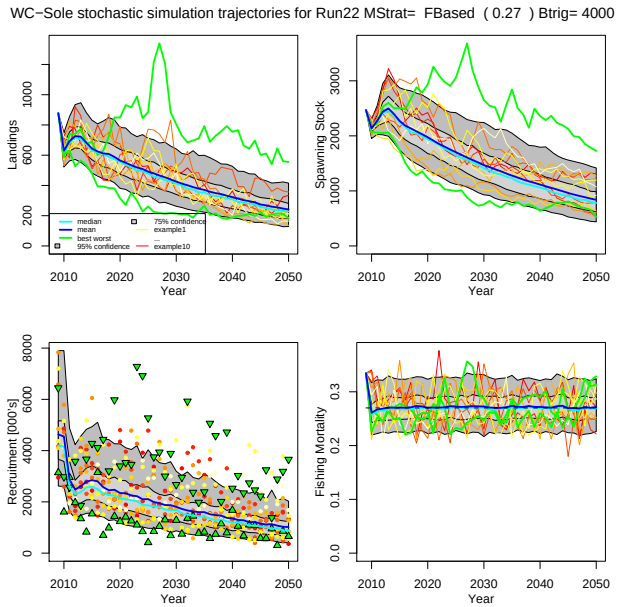

Figure43: Four plot summary results for simulations for Run22. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

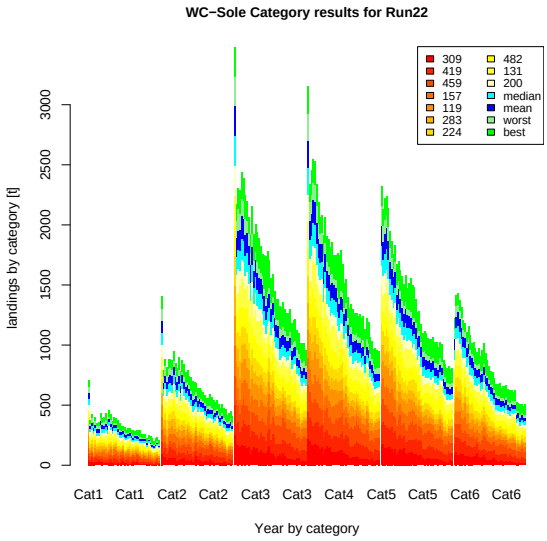

Figure44: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run22. Note that the height of the stacked bars is not equal to the average landings but a sum.

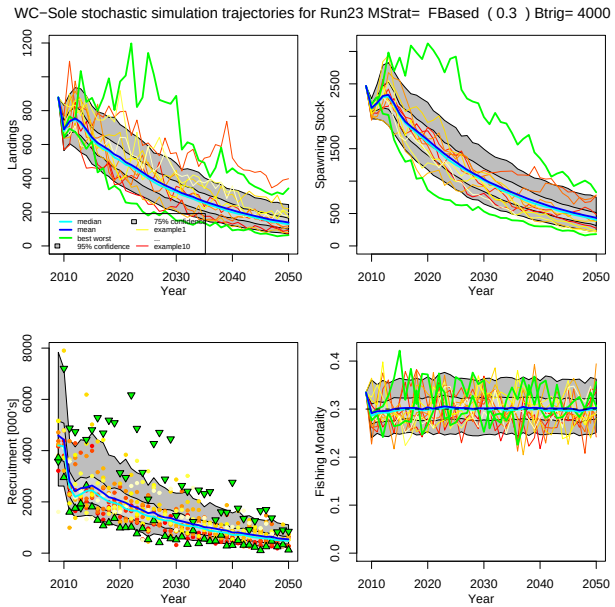

Figure45: Four plot summary results for simulations for Run23. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

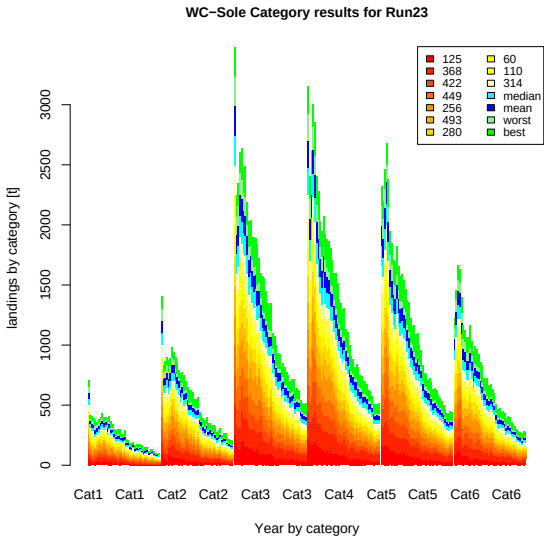

Figure46: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run23. Note that the height of the stacked bars is not equal to the average landings but a sum.

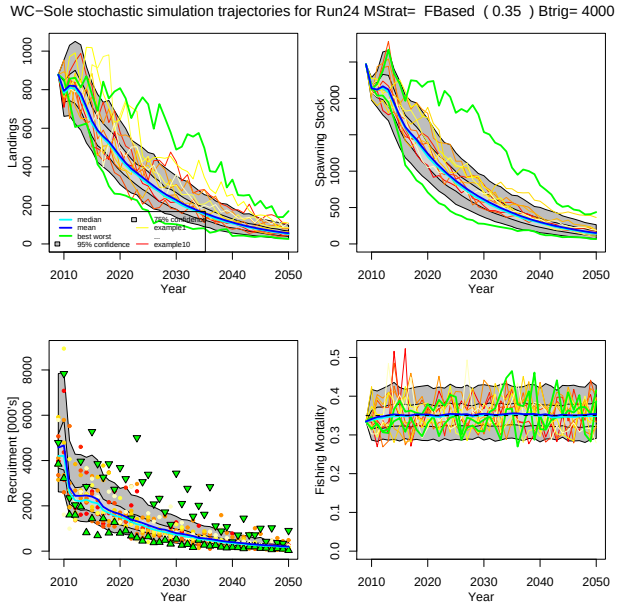

Figure47: Four plot summary results for simulations for Run24. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

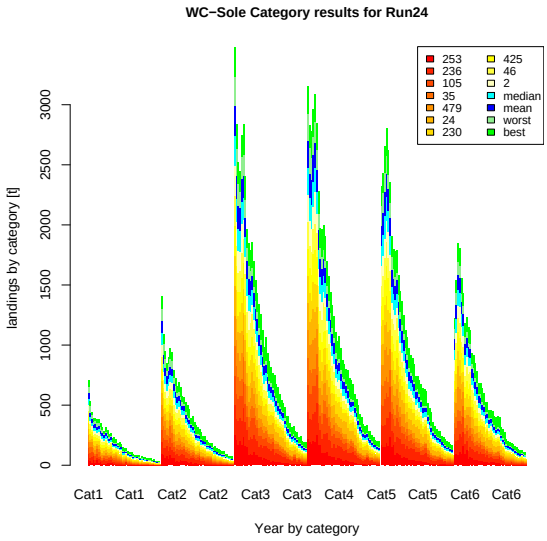

Figure48: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run24. Note that the height of the stacked bars is not equal to the average landings but a sum.

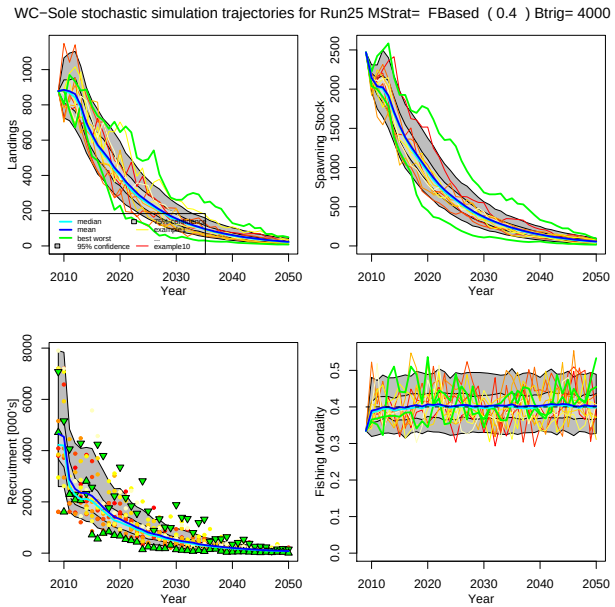

Figure49: Four plot summary results for simulations for Run25. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

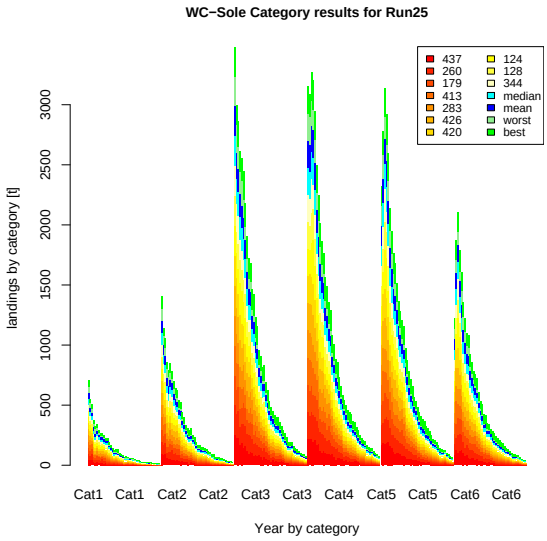

Figure50: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run25. Note that the height of the stacked bars is not equal to the average landings but a sum.

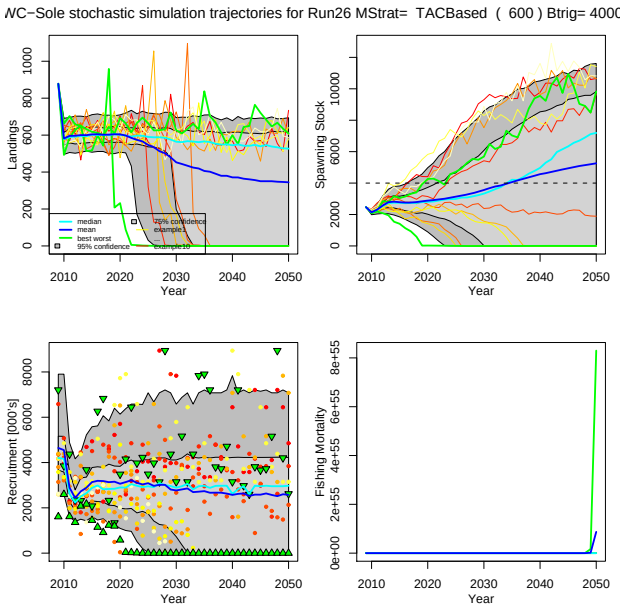

Figure51: Four plot summary results for simulations for Run26. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

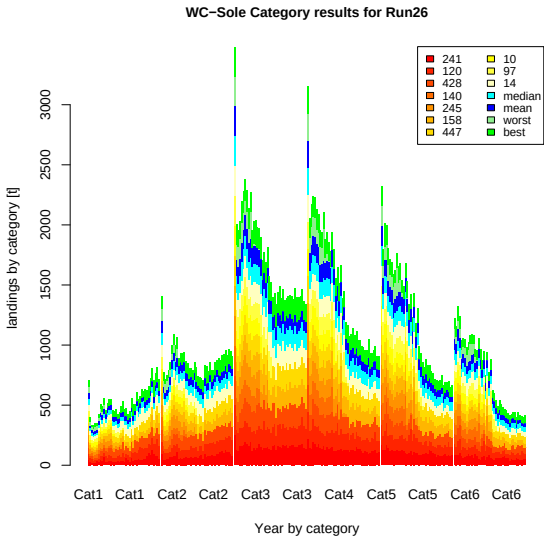

Figure52: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run26. Note that the height of the stacked bars is not equal to the average landings but a sum.

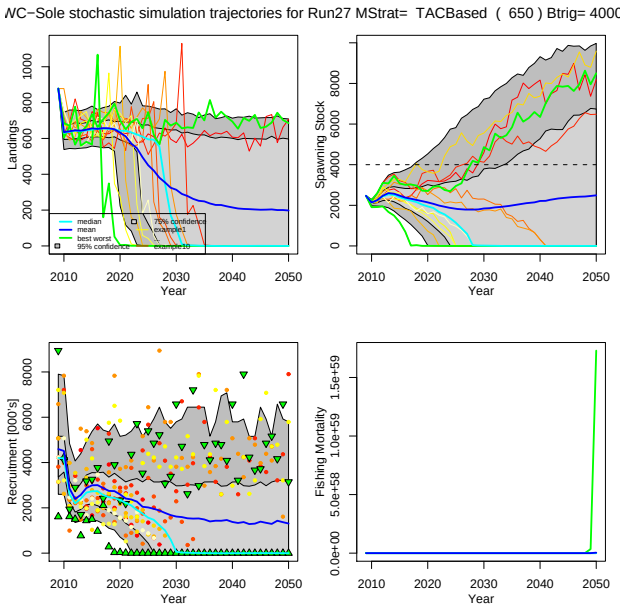

Figure53: Four plot summary results for simulations for Run27. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

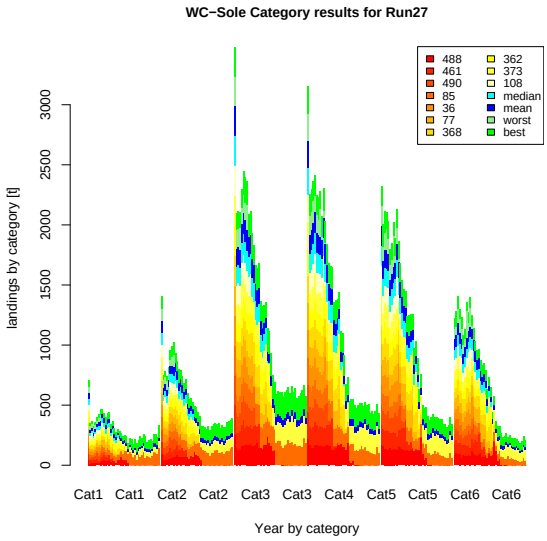

Figure54: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run27. Note that the height of the stacked bars is not equal to the average landings but a sum.

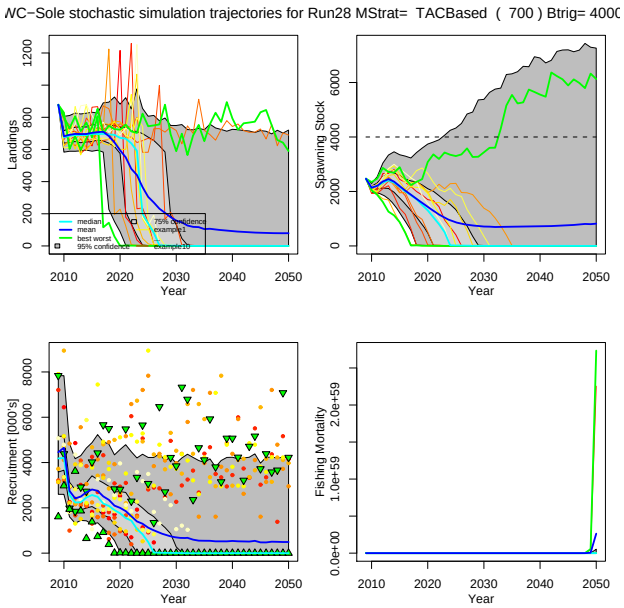

Figure55: Four plot summary results for simulations for Run28. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

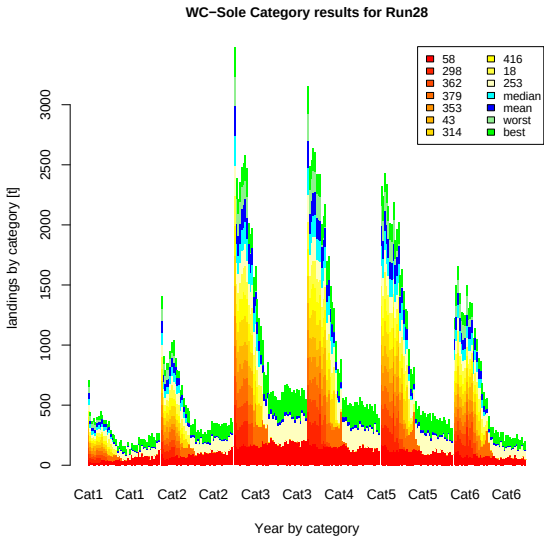

Figure56: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run28. Note that the height of the stacked bars is not equal to the average landings but a sum.

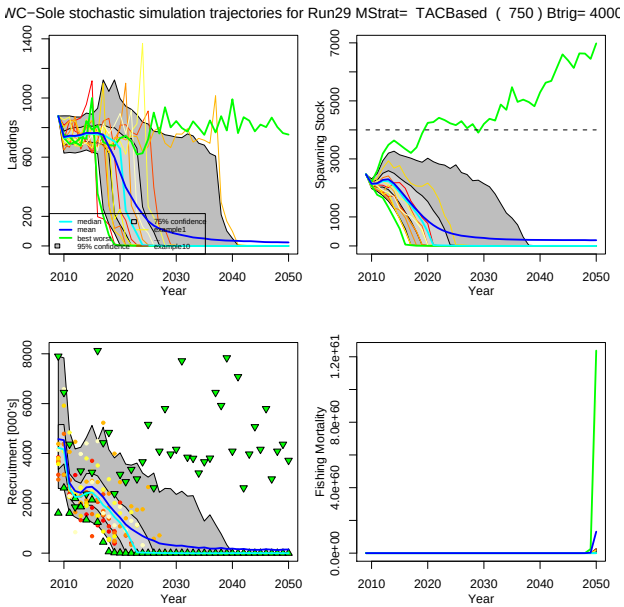

Figure57: Four plot summary results for simulations for Run29. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

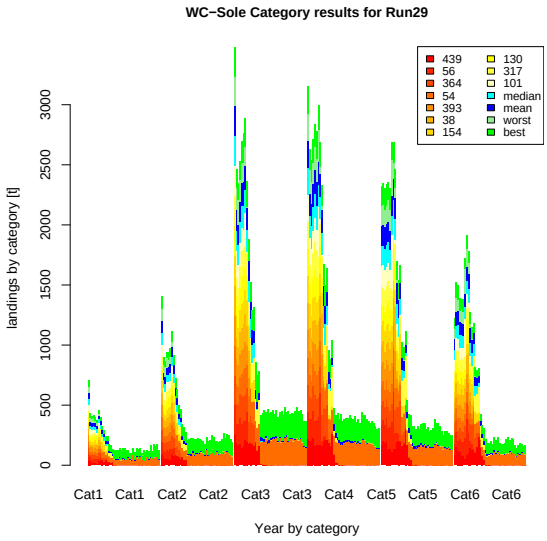

Figure58: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run29. Note that the height of the stacked bars is not equal to the average landings but a sum.

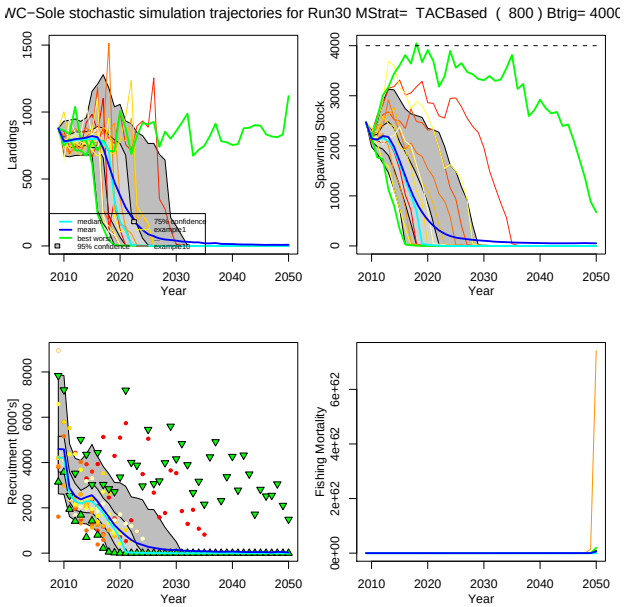

Figure59: Four plot summary results for simulations for Run30. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

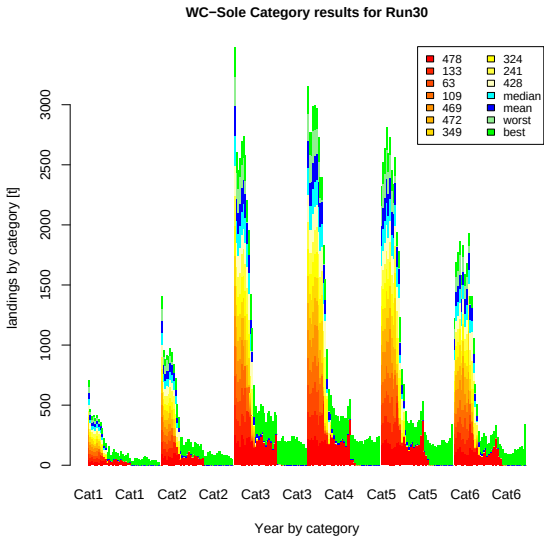

Figure60: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run30. Note that the height of the stacked bars is not equal to the average landings but a sum.

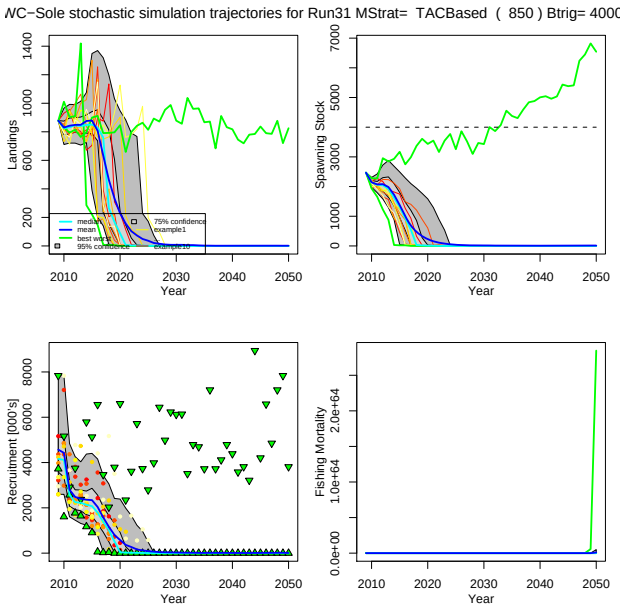

Figure61: Four plot summary results for simulations for Run31. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

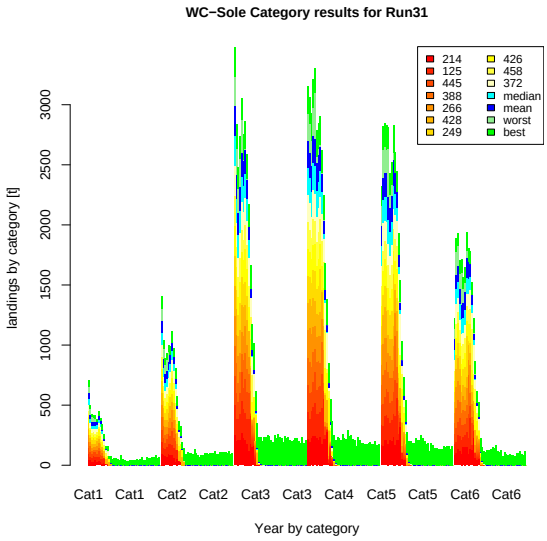

Figure62: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run31. Note that the height of the stacked bars is not equal to the average landings but a sum.

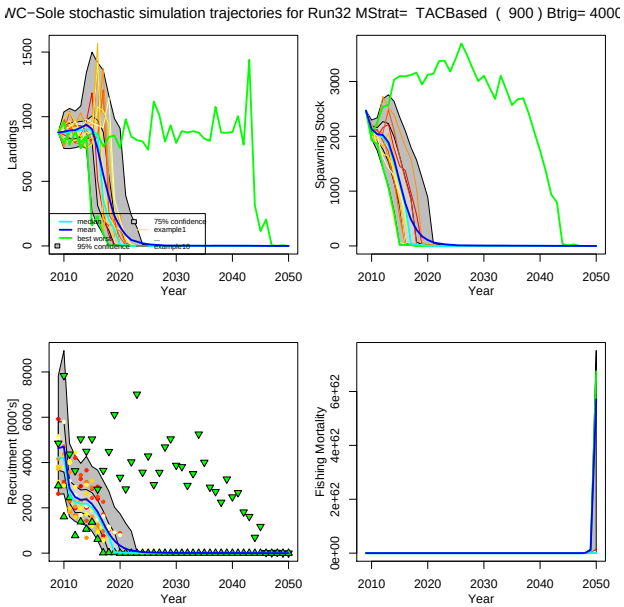

Figure63: Four plot summary results for simulations for Run32. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

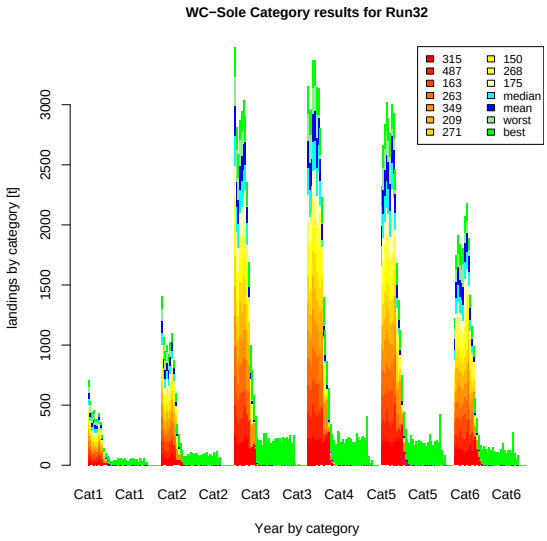

Figure64: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run32. Note that the height of the stacked bars is not equal to the average landings but a sum.

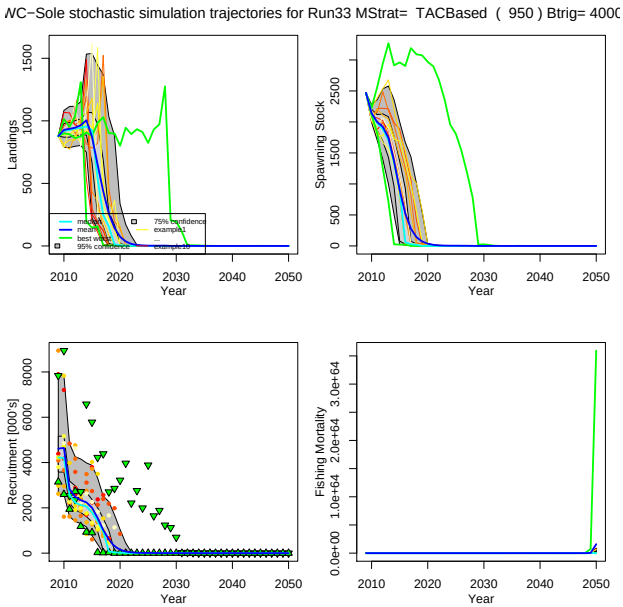

Figure65: Four plot summary results for simulations for Run33. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

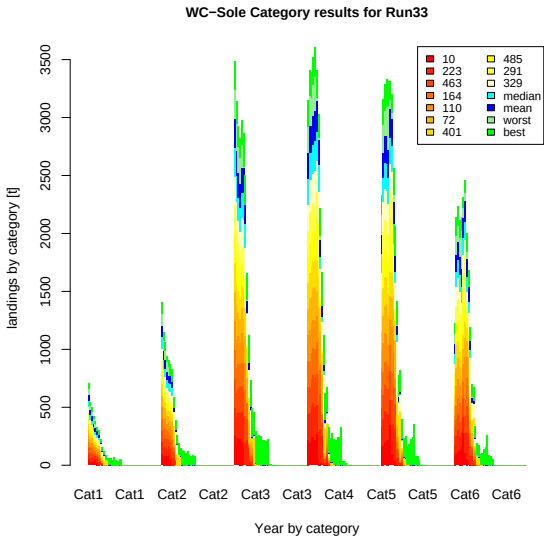

Figure66: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run33. Note that the height of the stacked bars is not equal to the average landings but a sum.

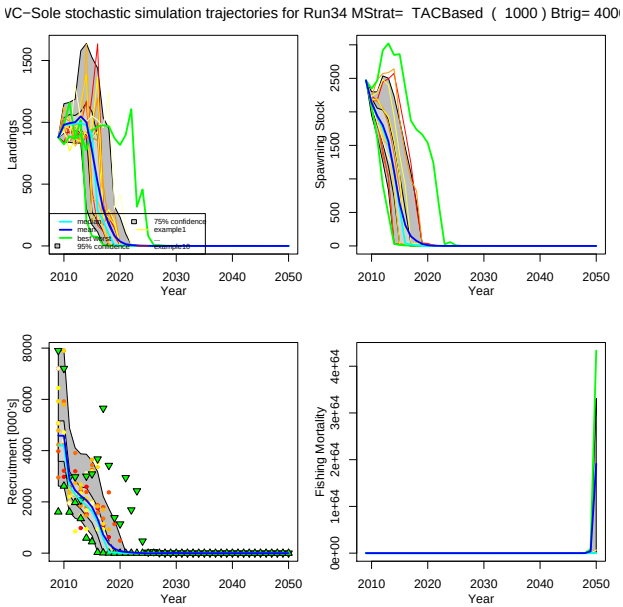

Figure67: Four plot summary results for simulations for Run34. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

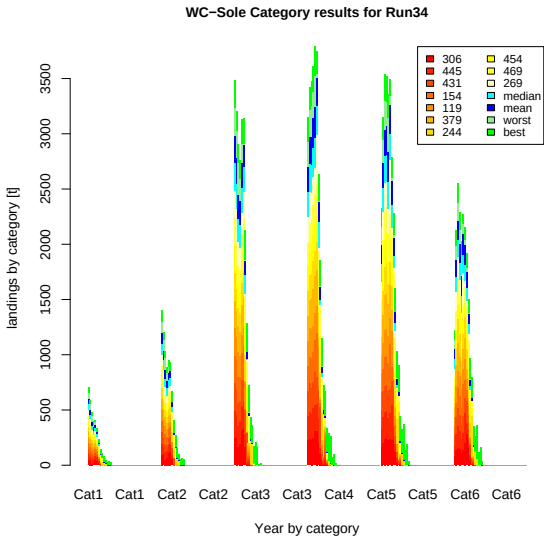

Figure68: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run34. Note that the height of the stacked bars is not equal to the average landings but a sum.

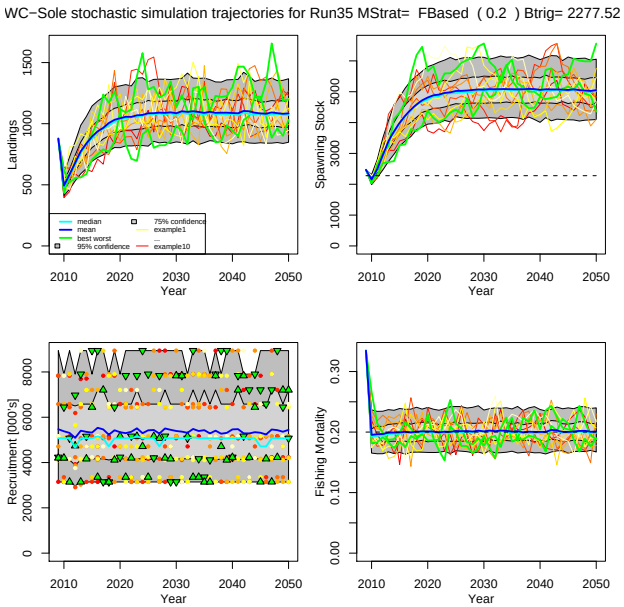

Figure69: Four plot summary results for simulations for Run35. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

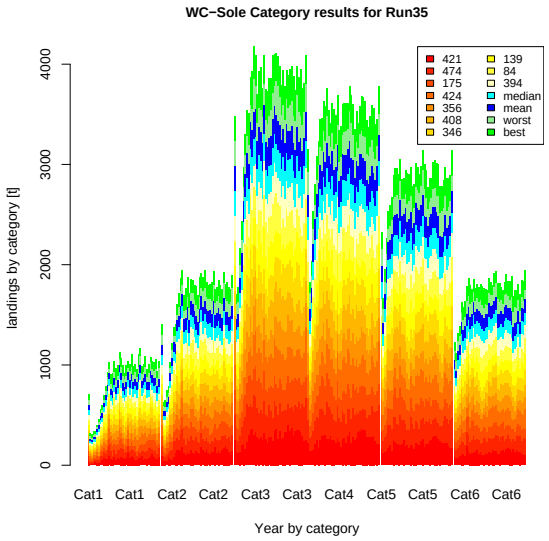

Figure70: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run35. Note that the height of the stacked bars is not equal to the average landings but a sum.

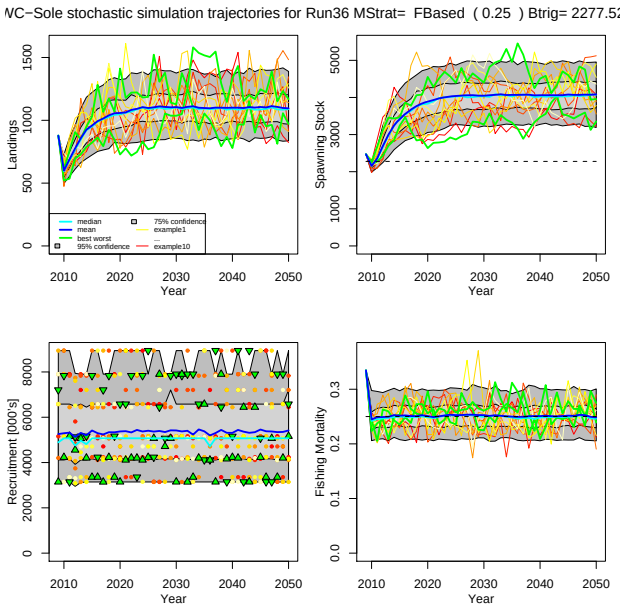

Figure71: Four plot summary results for simulations for Run36. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

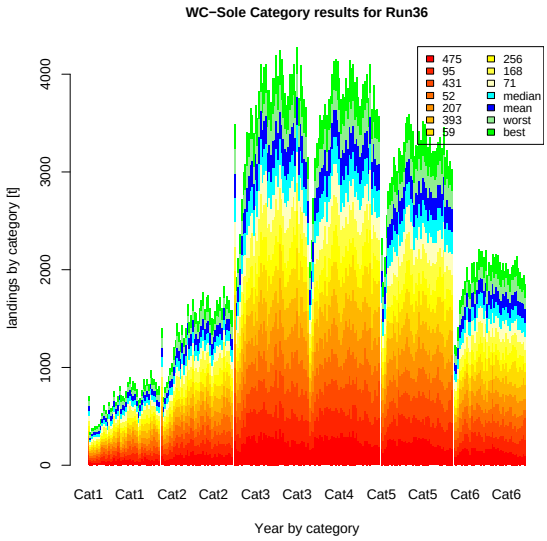

Figure72: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run36. Note that the height of the stacked bars is not equal to the average landings but a sum.

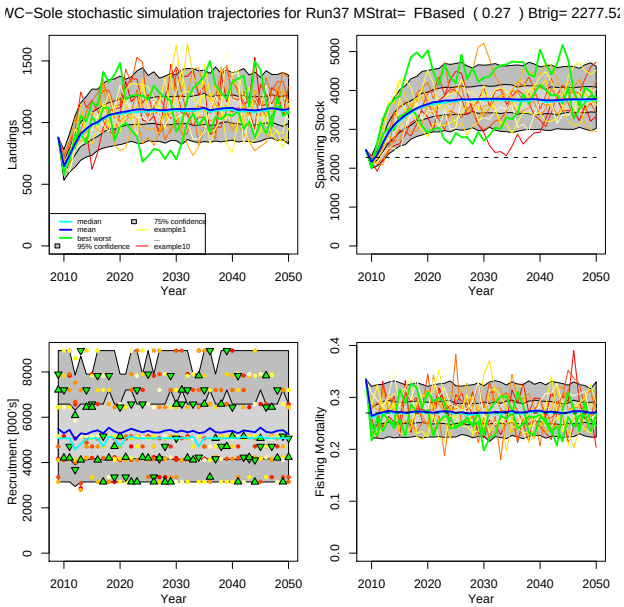

Figure73: Four plot summary results for simulations for Run37. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

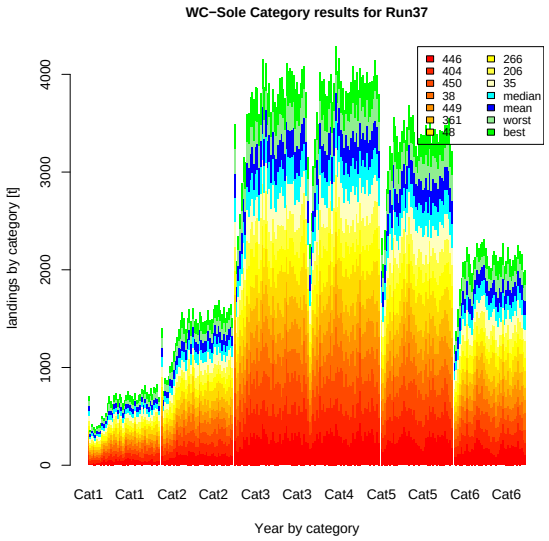

Figure74: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run37. Note that the height of the stacked bars is not equal to the average landings but a sum.

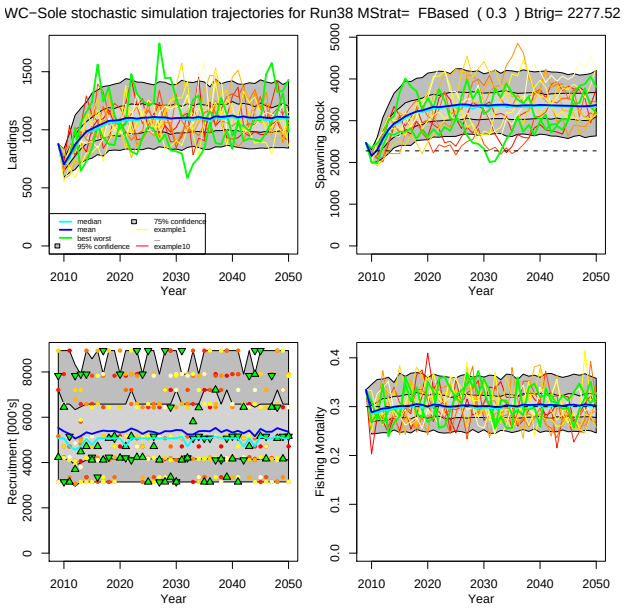

Figure75: Four plot summary results for simulations for Run38. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

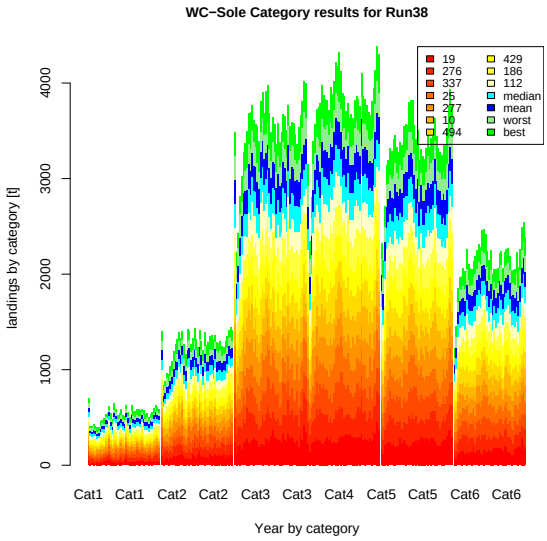

Figure76: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run38. Note that the height of the stacked bars is not equal to the average landings but a sum.

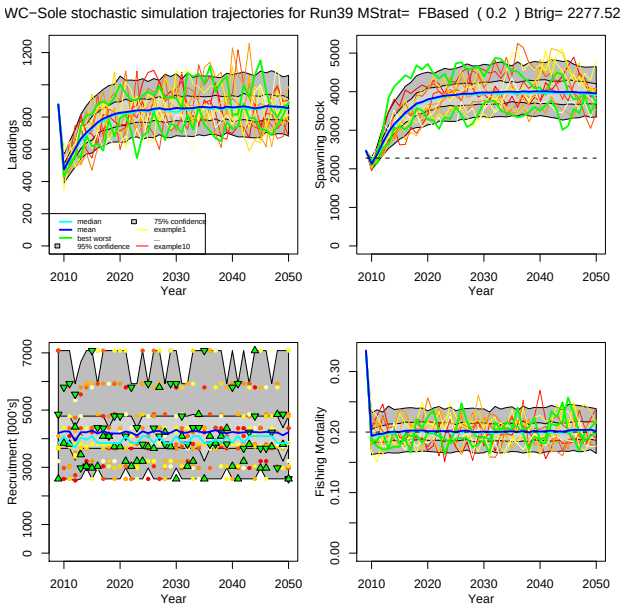

Figure77: Four plot summary results for simulations for Run39. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

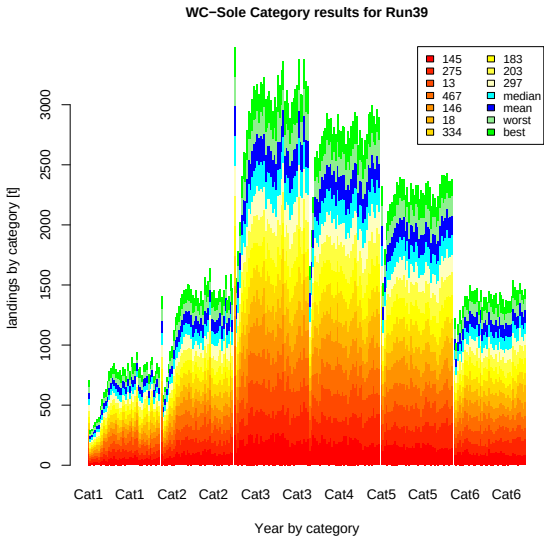

Figure78: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run39. Note that the height of the stacked bars is not equal to the average landings but a sum.

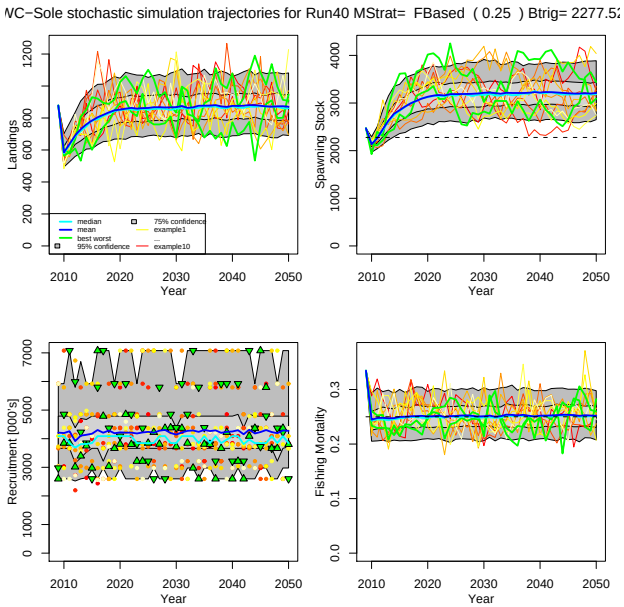

Figure79: Four plot summary results for simulations for Run40. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

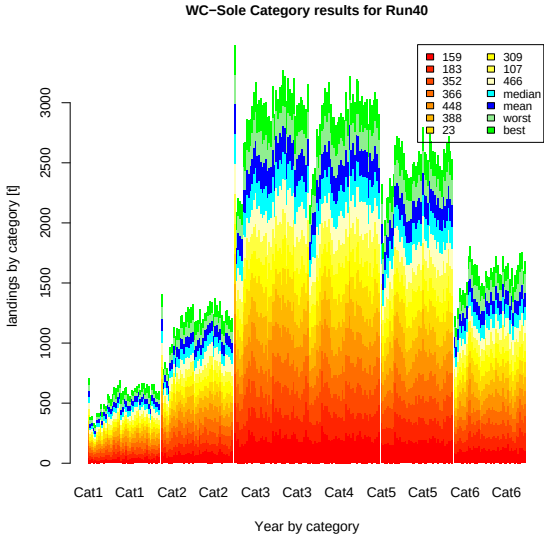

Figure80: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run40. Note that the height of the stacked bars is not equal to the average landings but a sum.

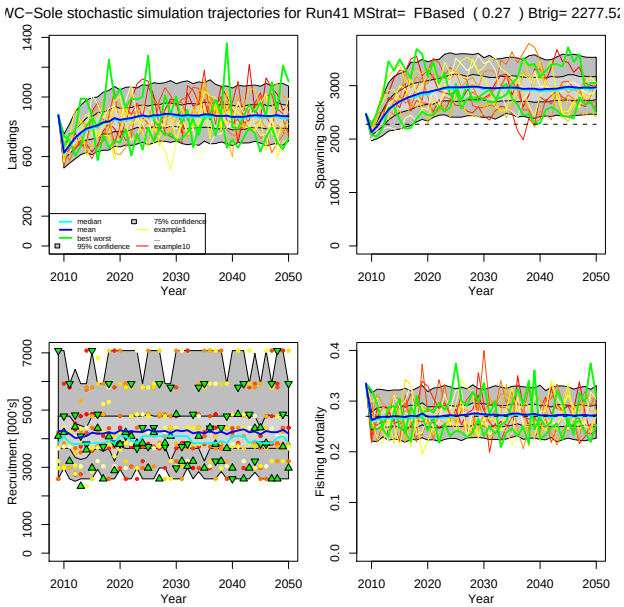

Figure81: Four plot summary results for simulations for Run41. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

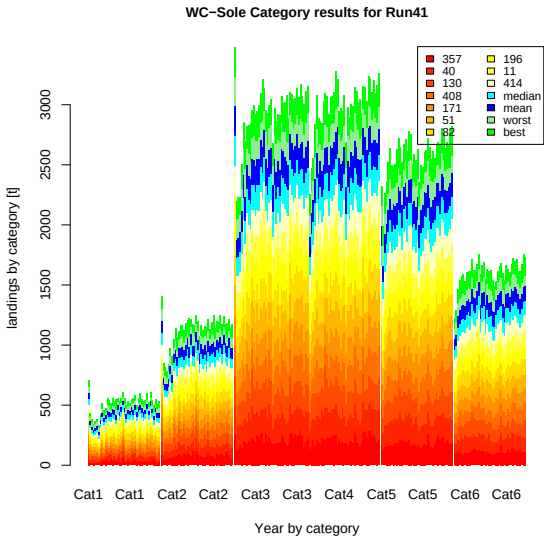

Figure82: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run41. Note that the height of the stacked bars is not equal to the average landings but a sum.

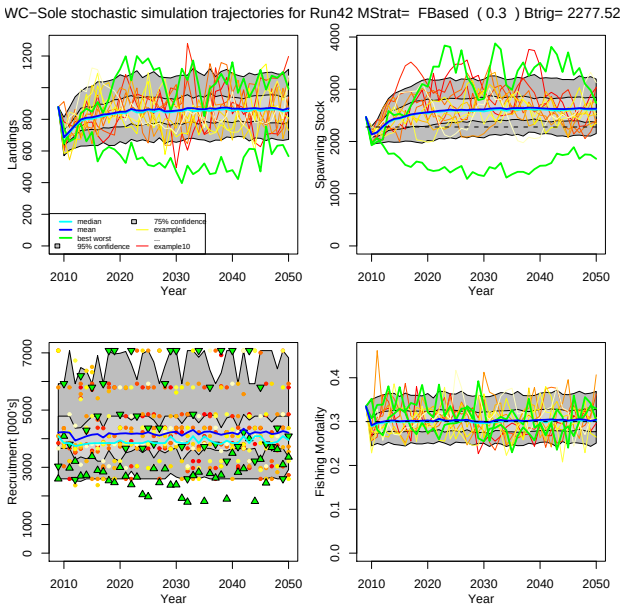

Figure83: Four plot summary results for simulations for Run42. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

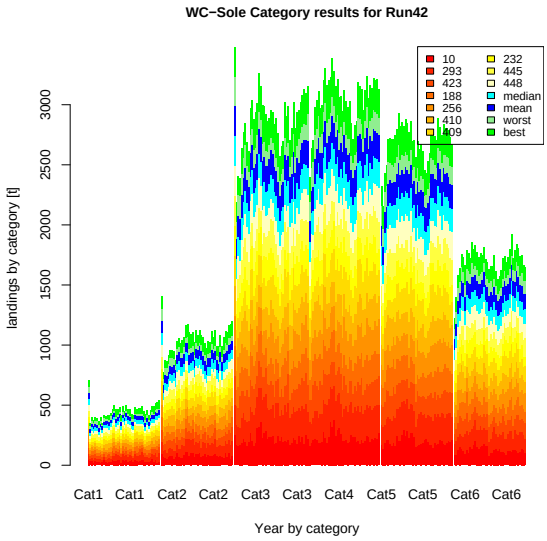

Figure84: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run42. Note that the height of the stacked bars is not equal to the average landings but a sum.

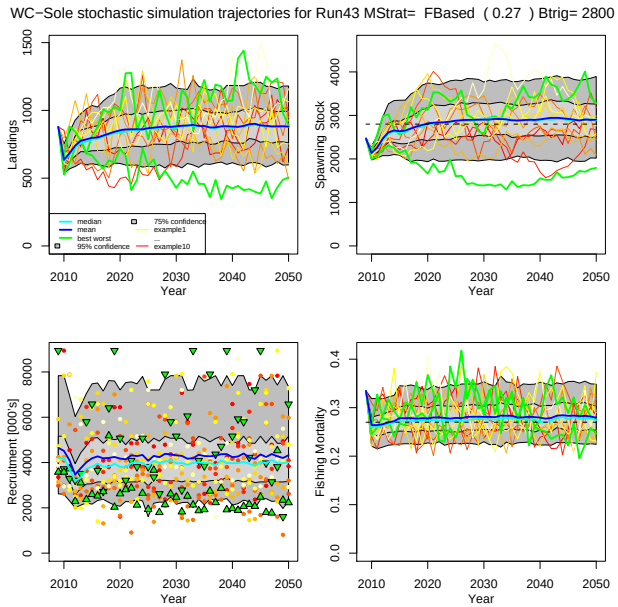

Figure85: Four plot summary results for simulations for Run43. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

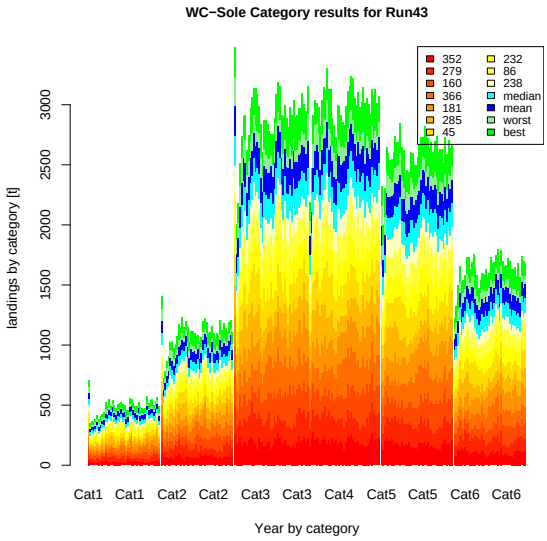

Figure86: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run43. Note that the height of the stacked bars is not equal to the average landings but a sum.

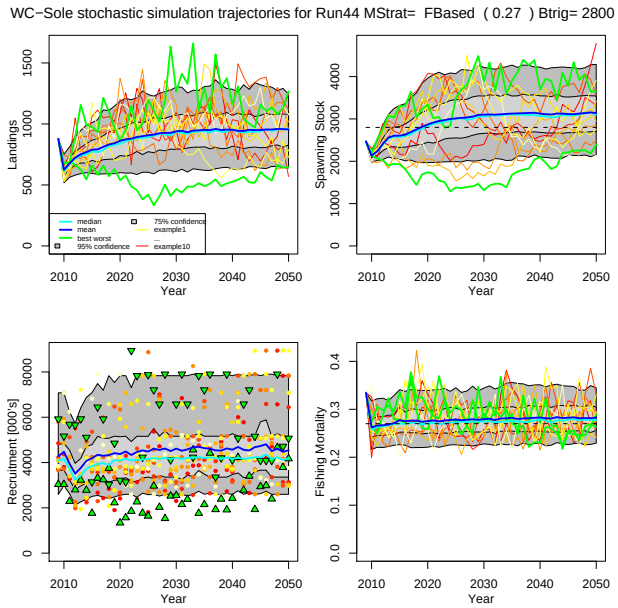

Figure87: Four plot summary results for simulations for Run44. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

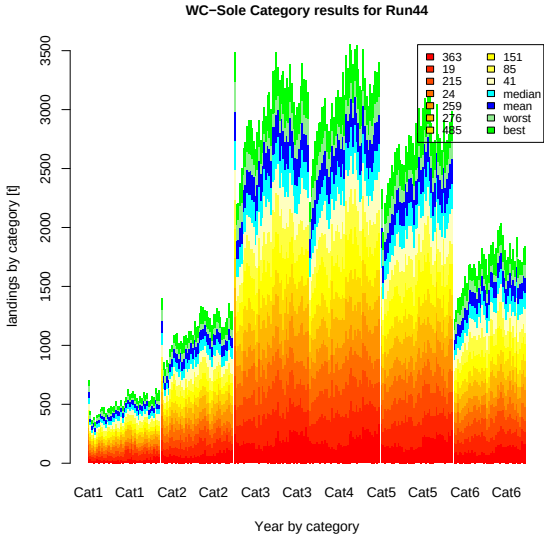

Figure88: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run44. Note that the height of the stacked bars is not equal to the average landings but a sum.

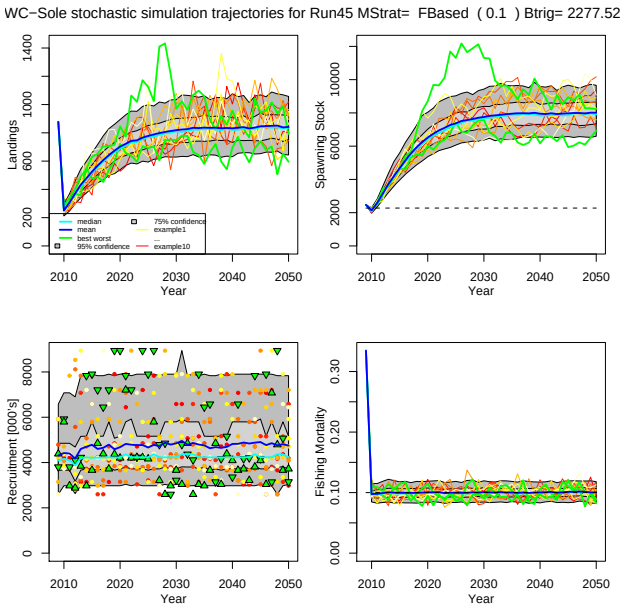

Figure89: Four plot summary results for simulations for Run45. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

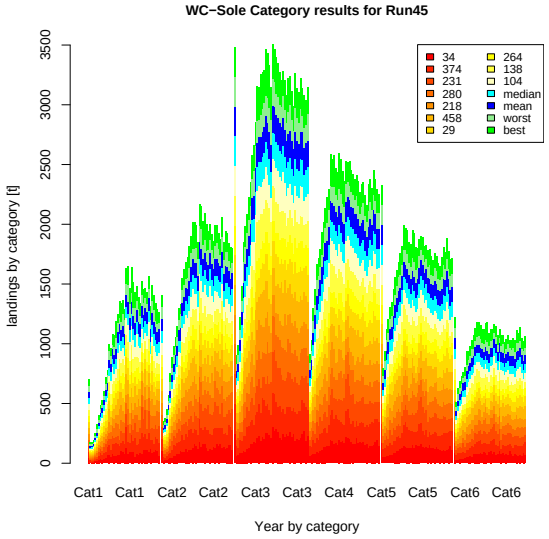

Figure90: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run45. Note that the height of the stacked bars is not equal to the average landings but a sum.

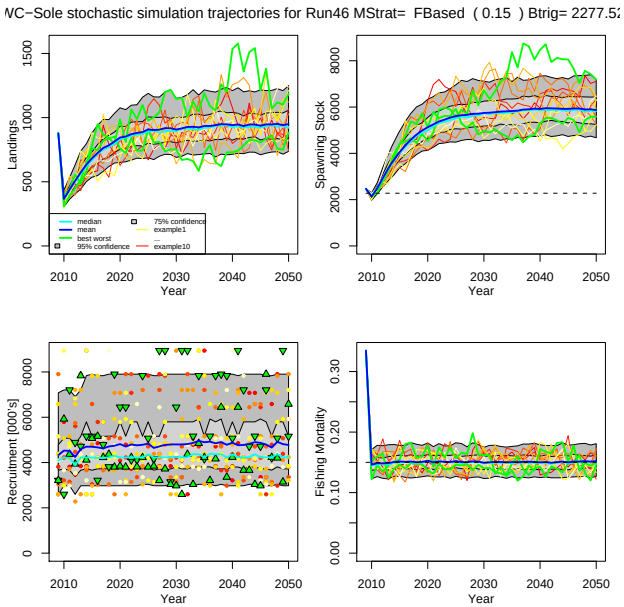

Figure91: Four plot summary results for simulations for Run46. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

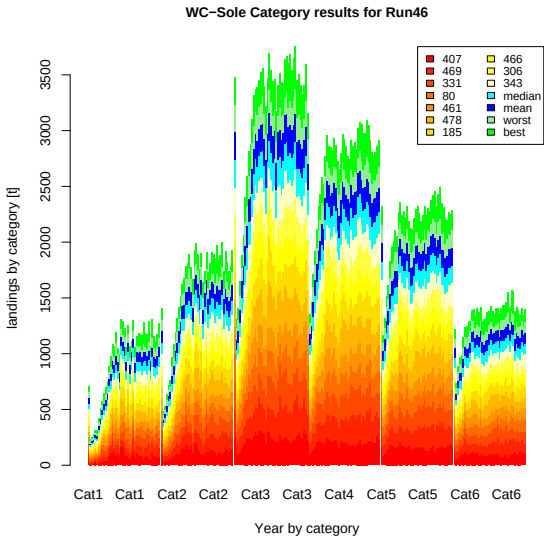

Figure92: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run46. Note that the height of the stacked bars is not equal to the average landings but a sum.

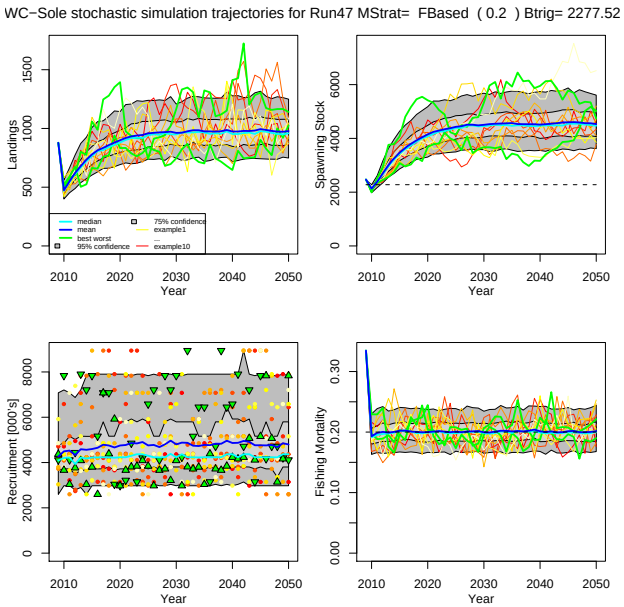

Figure93: Four plot summary results for simulations for Run47. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

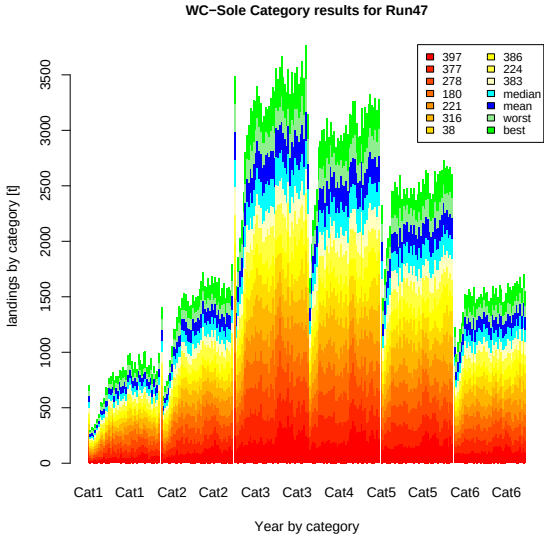

Figure94: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run47. Note that the height of the stacked bars is not equal to the average landings but a sum.

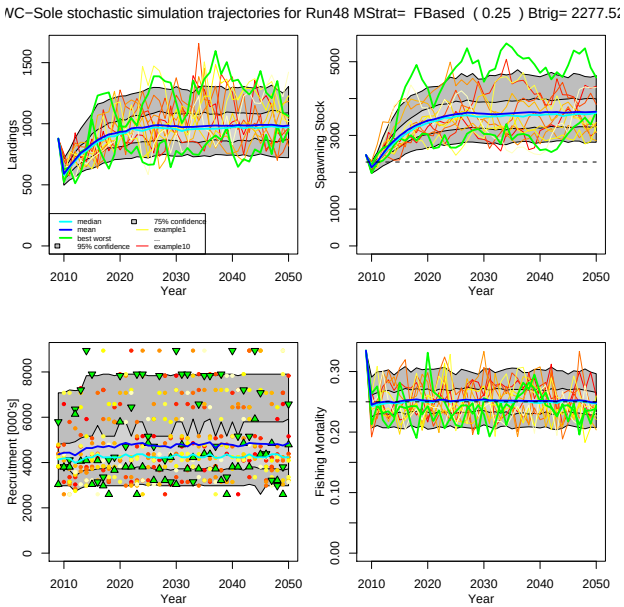

Figure95: Four plot summary results for simulations for Run48. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

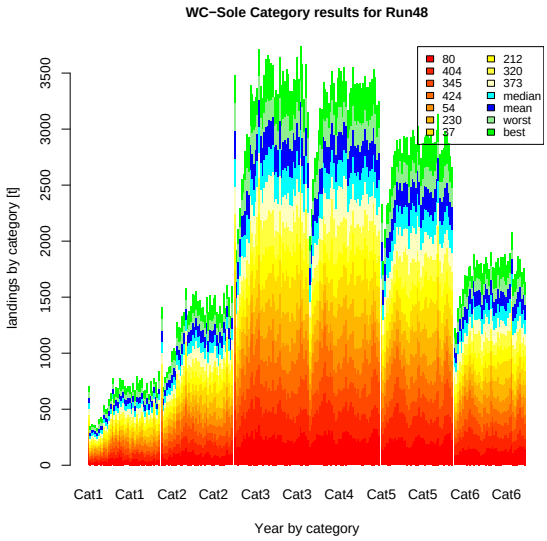

Figure96: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run48. Note that the height of the stacked bars is not equal to the average landings but a sum.

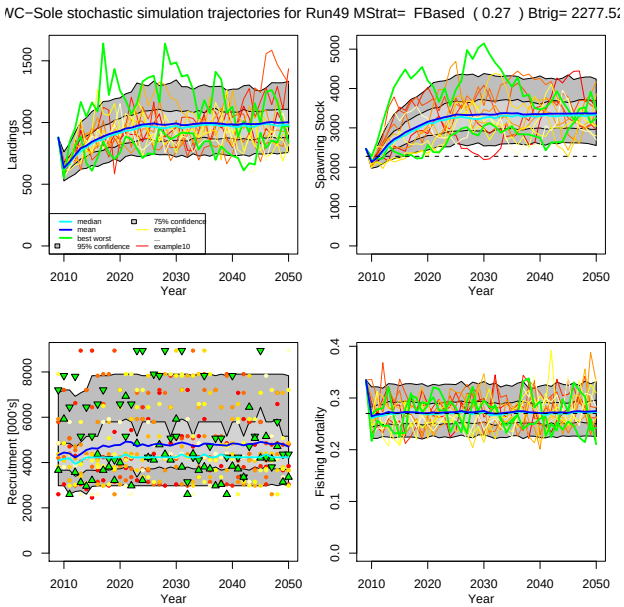

Figure97: Four plot summary results for simulations for Run49. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

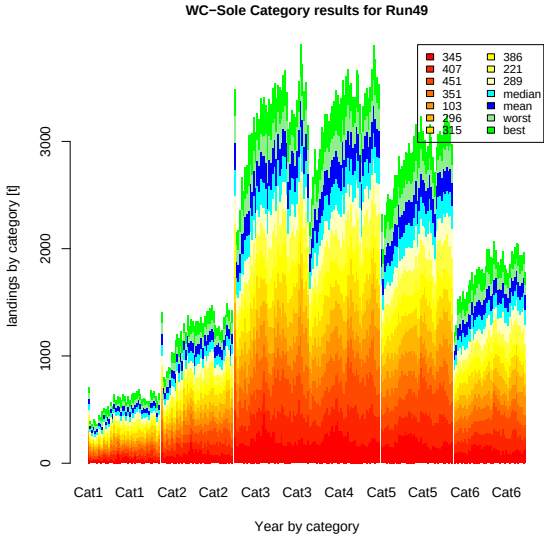

Figure98: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run49. Note that the height of the stacked bars is not equal to the average landings but a sum.

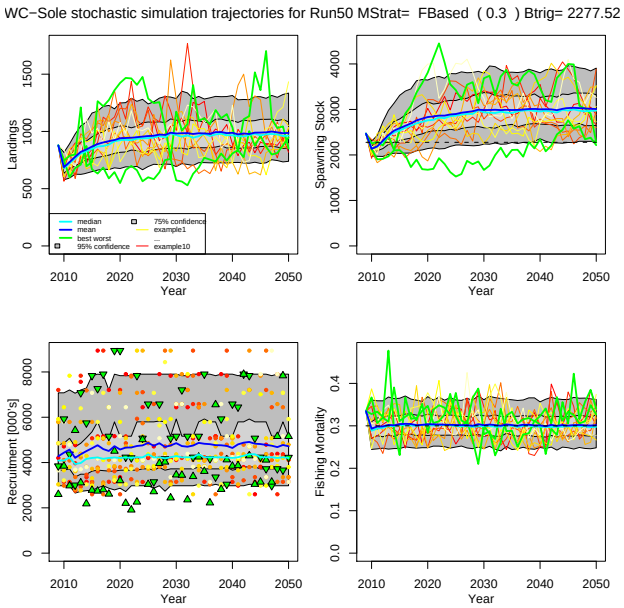

Figure99: Four plot summary results for simulations for Run50. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

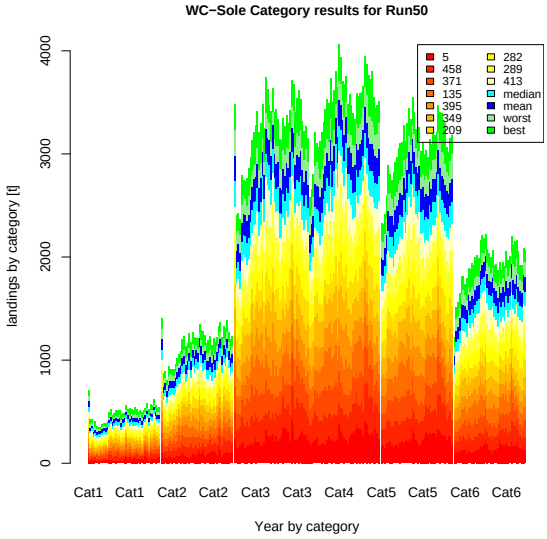

Figure100: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run50. Note that the height of the stacked bars is not equal to the average landings but a sum.

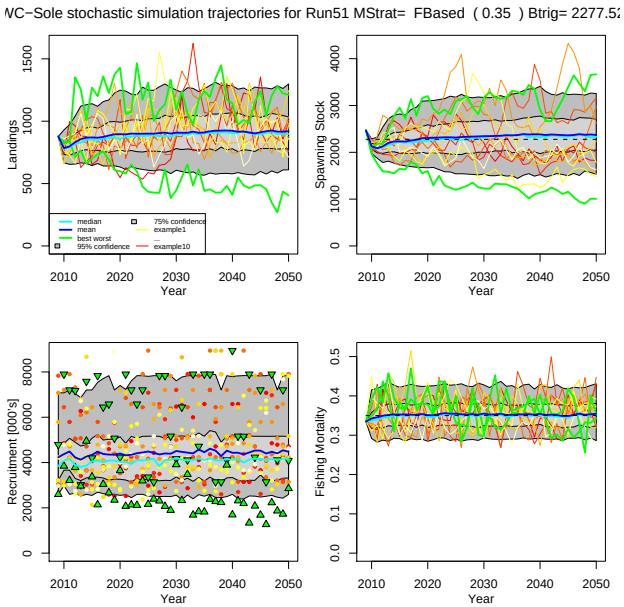

Figure101: Four plot summary results for simulations for Run51. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

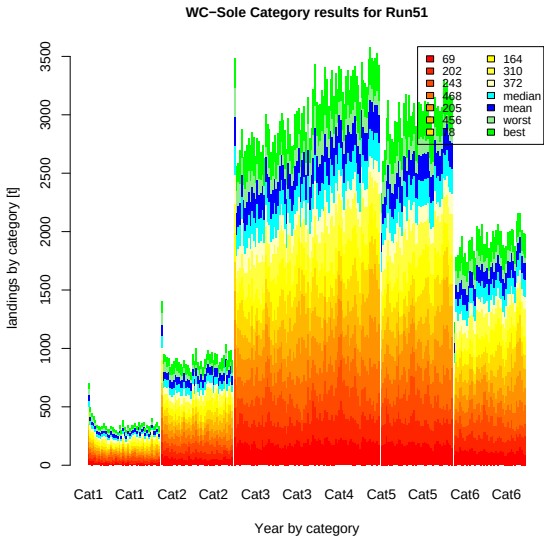

Figure102: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run51. Note that the height of the stacked bars is not equal to the average landings but a sum.

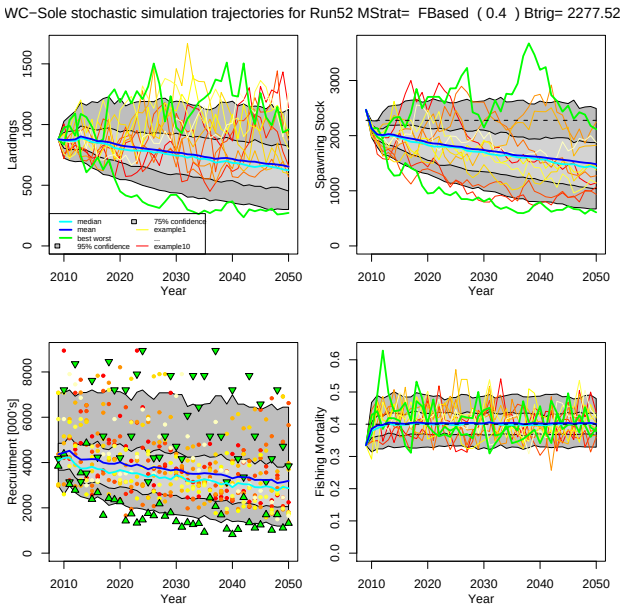

Figure103: Four plot summary results for simulations for Run52. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

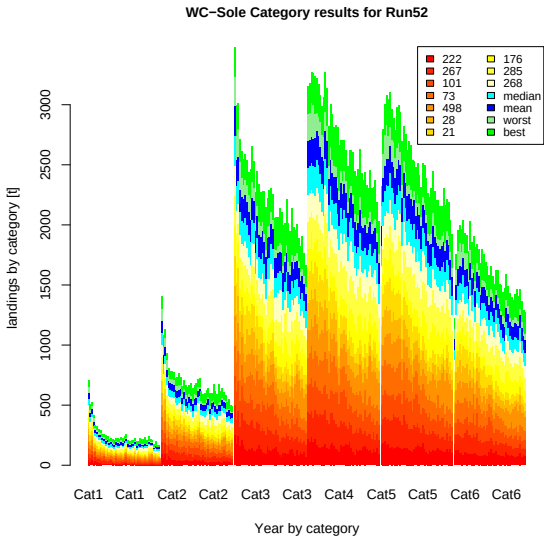

Figure104: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run52. Note that the height of the stacked bars is not equal to the average landings but a sum.

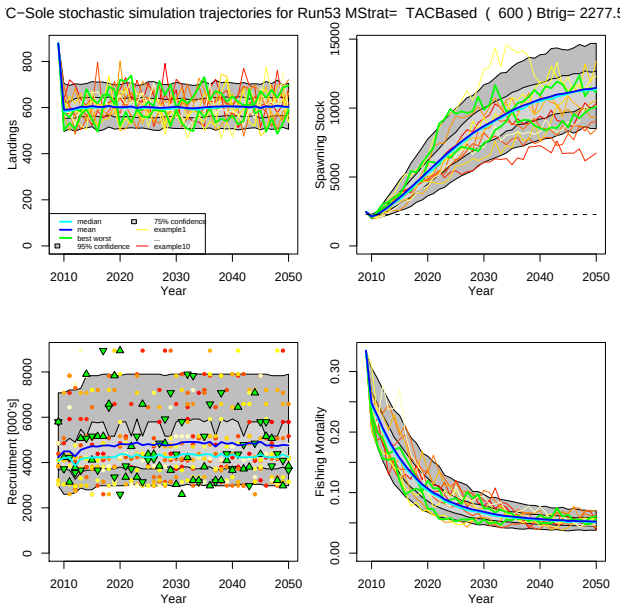

Figure105: Four plot summary results for simulations for Run53. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

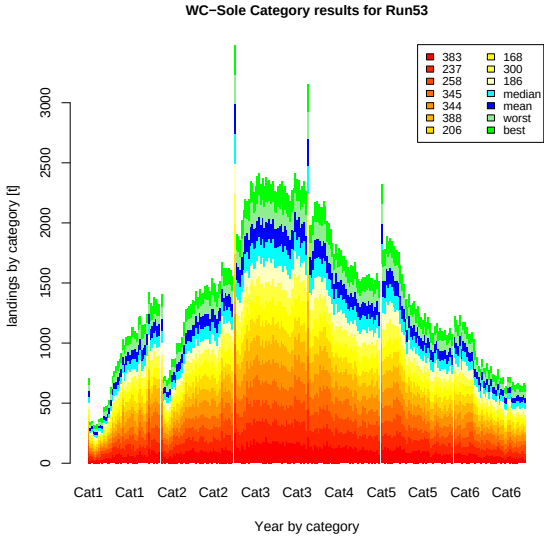

Figure106: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run53. Note that the height of the stacked bars is not equal to the average landings but a sum.

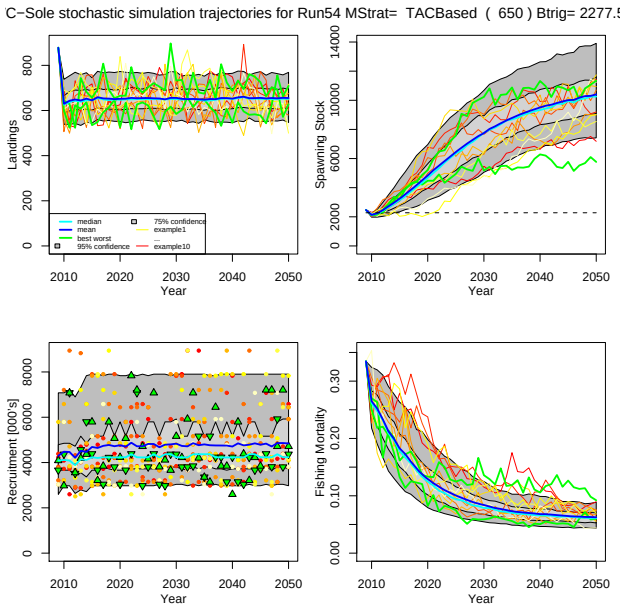

Figure107: Four plot summary results for simulations for Run54. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

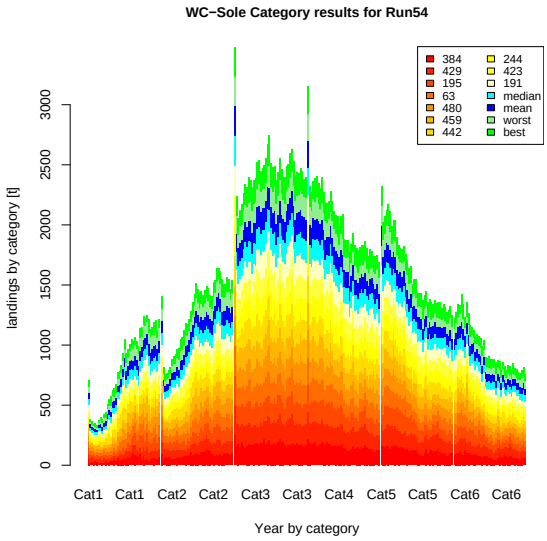

Figure108: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run54. Note that the height of the stacked bars is not equal to the average landings but a sum.

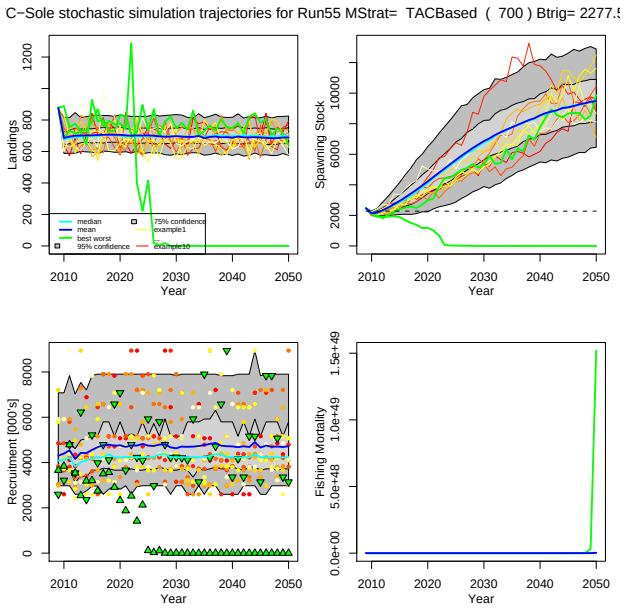

Figure109: Four plot summary results for simulations for Run55. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

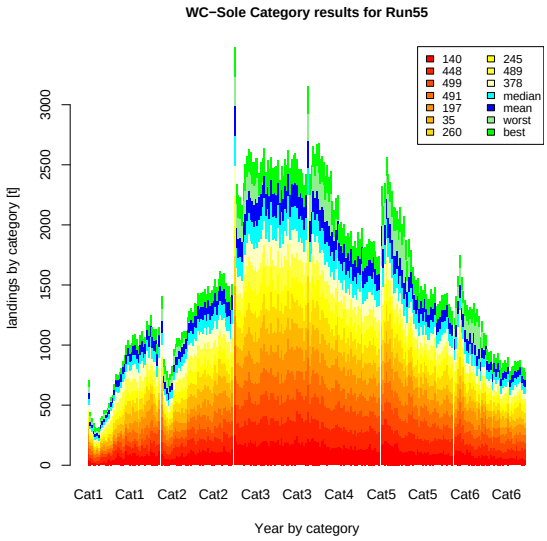

Figure110: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run55. Note that the height of the stacked bars is not equal to the average landings but a sum.

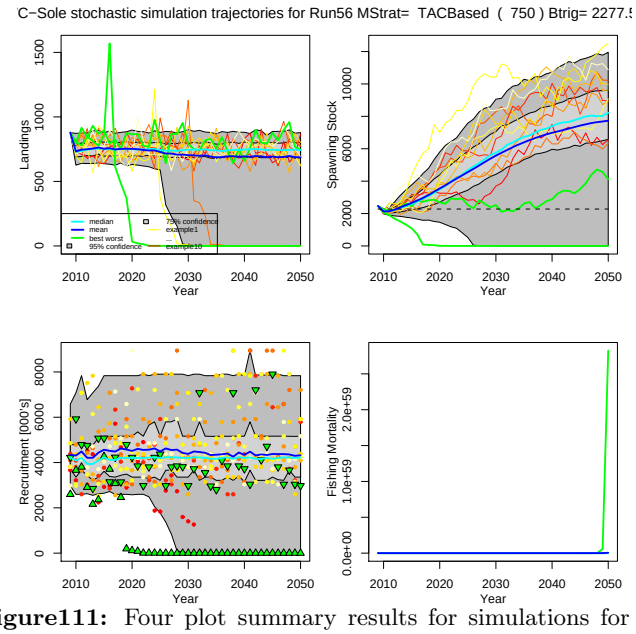

Figure111: Four plot summary results for simulations for Run56. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

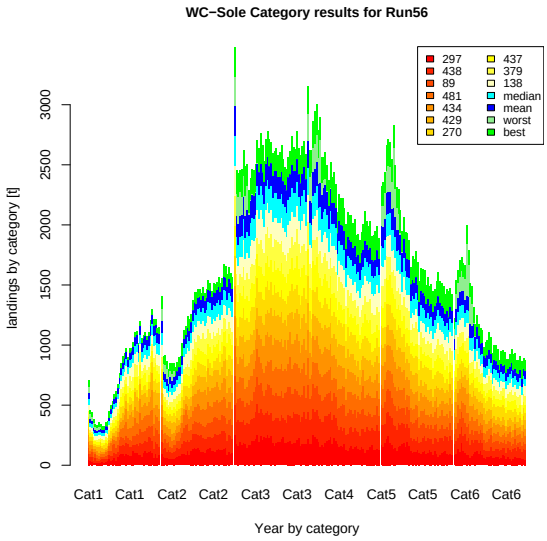

Figure112: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run56. Note that the height of the stacked bars is not equal to the average landings but a sum.

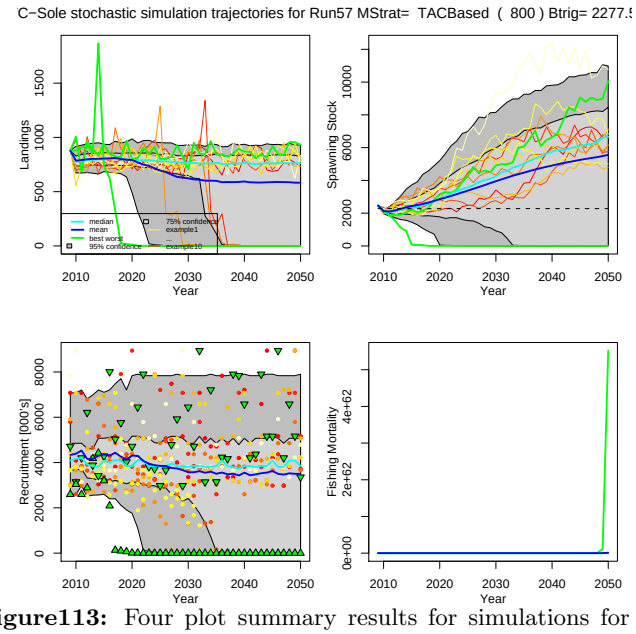

Figure113: Four plot summary results for simulations for Run57. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

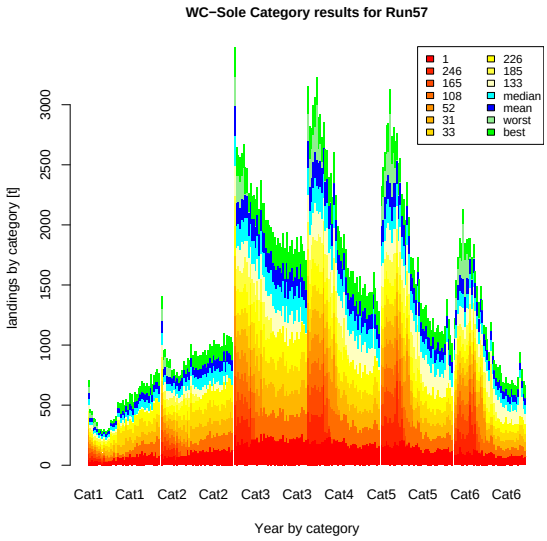

Figure114: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run57. Note that the height of the stacked bars is not equal to the average landings but a sum.

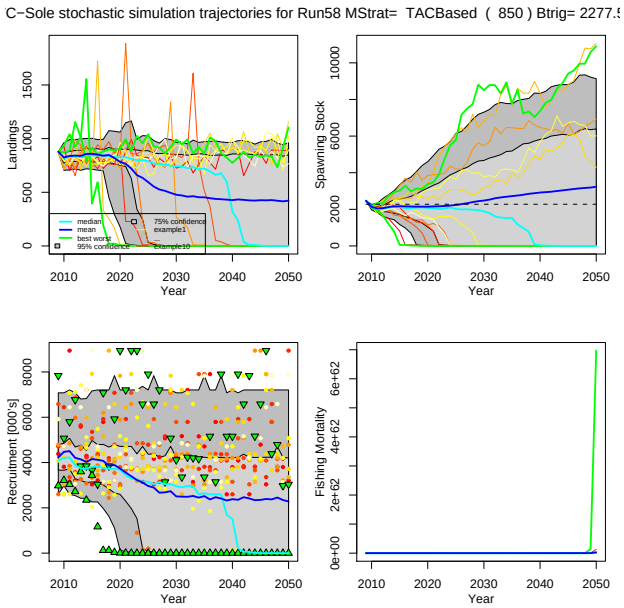

Figure115: Four plot summary results for simulations for Run58. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

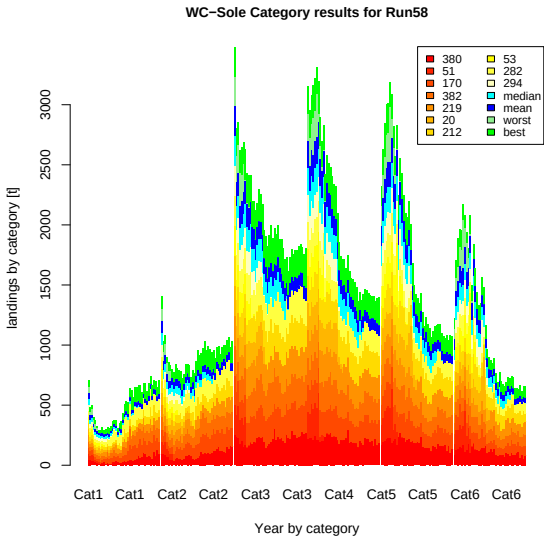

Figure116: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run58. Note that the height of the stacked bars is not equal to the average landings but a sum.

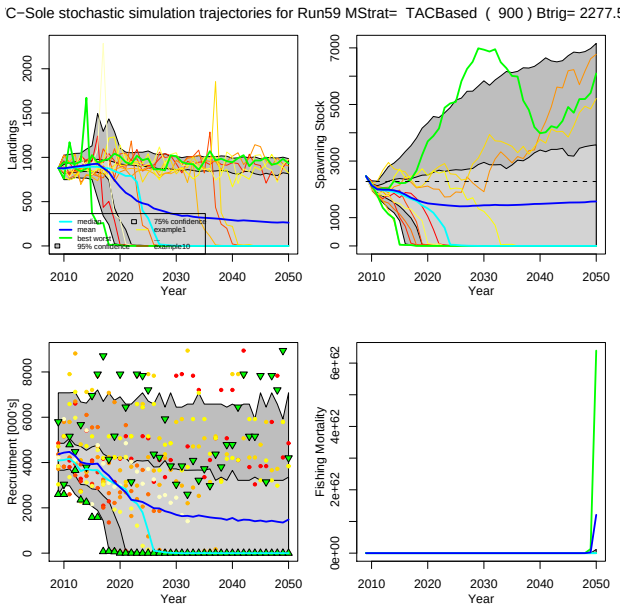

Figure117: Four plot summary results for simulations for Run59. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

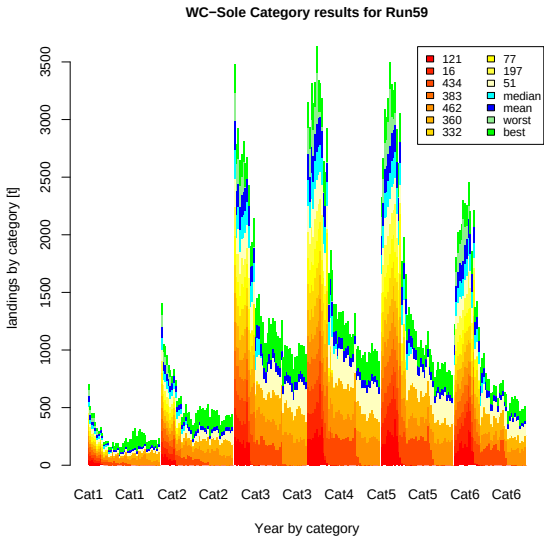

Figure118: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run59. Note that the height of the stacked bars is not equal to the average landings but a sum.

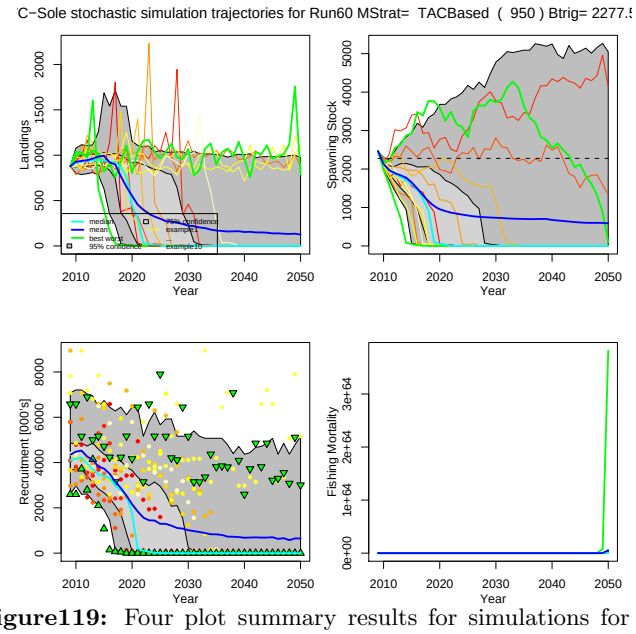

Figure119: Four plot summary results for simulations for Run60. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

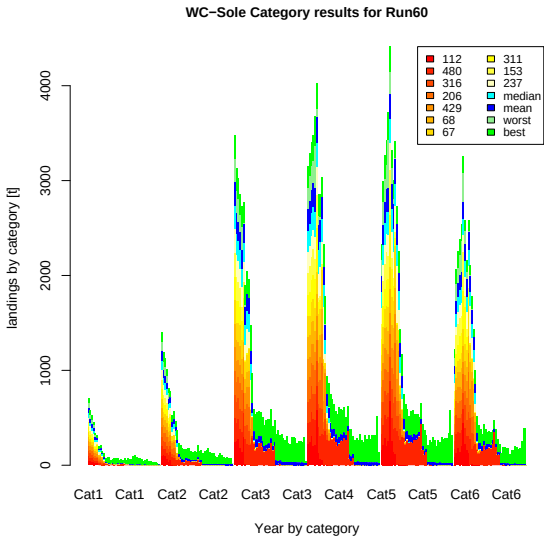

Figure120: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run60. Note that the height of the stacked bars is not equal to the average landings but a sum.

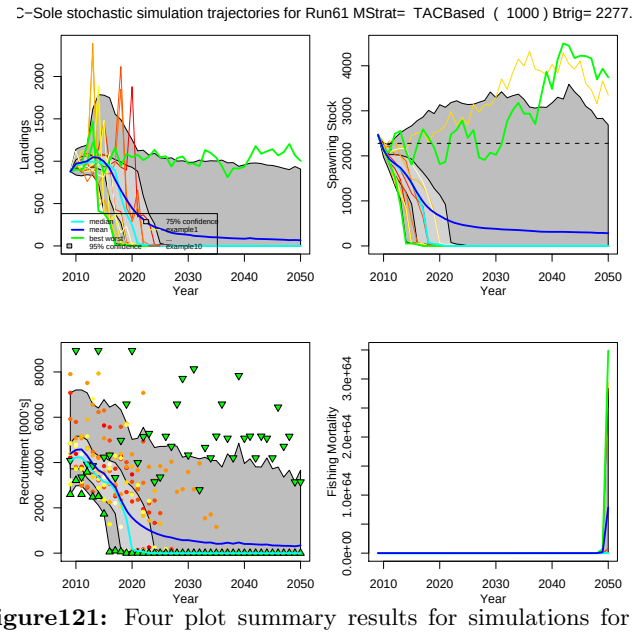

Figure121: Four plot summary results for simulations for Run61. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

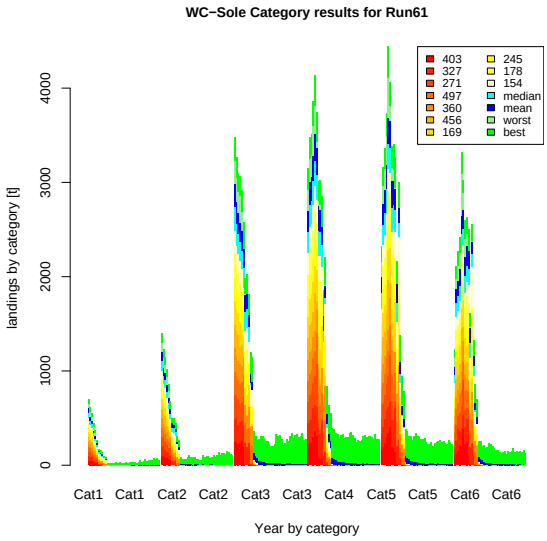

Figure122: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run61. Note that the height of the stacked bars is not equal to the average landings but a sum.

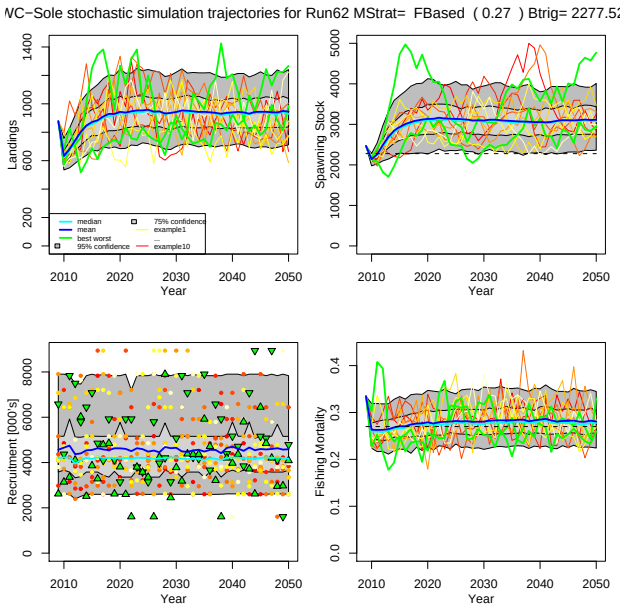

Figure123: Four plot summary results for simulations for Run62. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

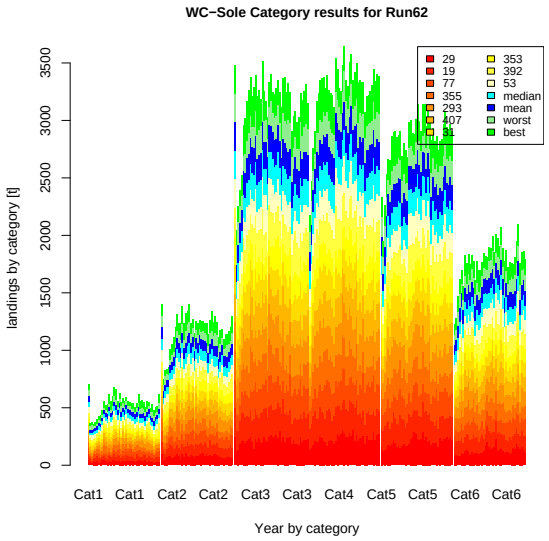

Figure124: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run62. Note that the height of the stacked bars is not equal to the average landings but a sum.

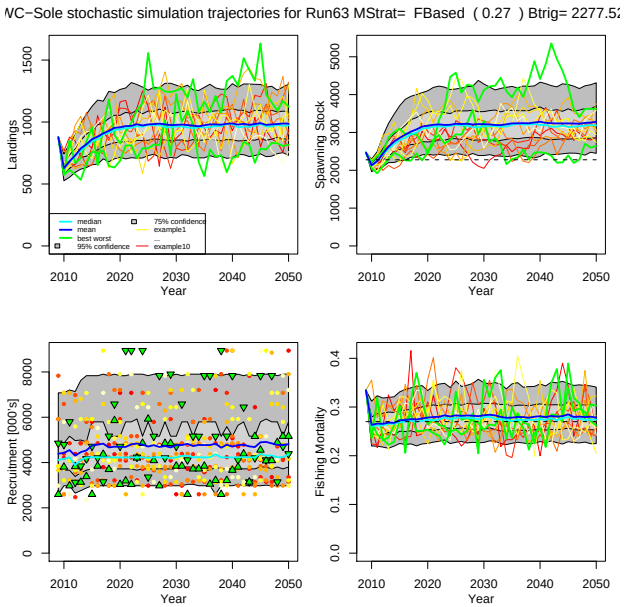

Figure125: Four plot summary results for simulations for Run63. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

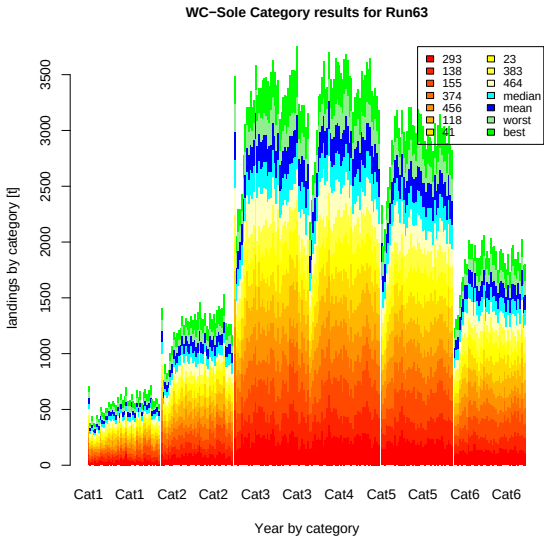

Figure126: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run63. Note that the height of the stacked bars is not equal to the average landings but a sum.

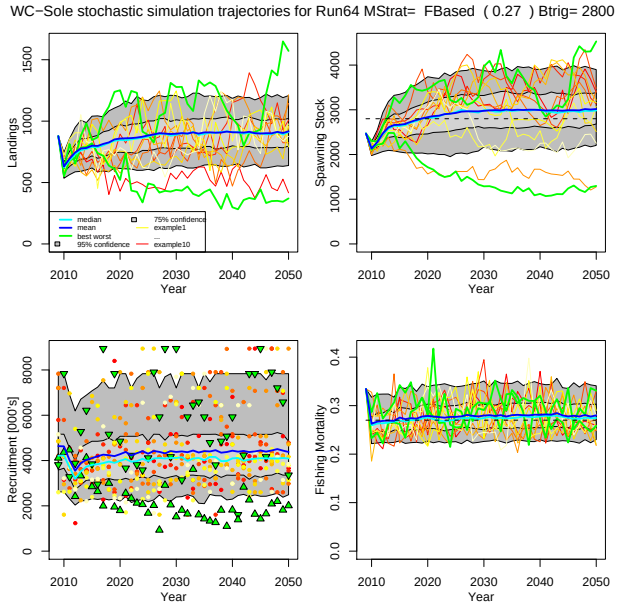

Figure127: Four plot summary results for simulations for Run64. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

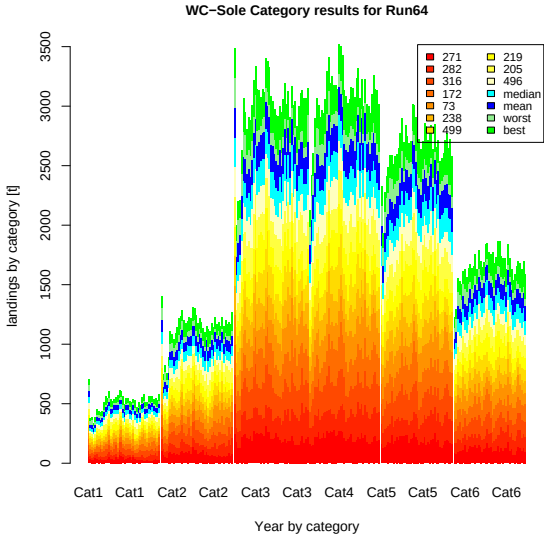

Figure128: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run64. Note that the height of the stacked bars is not equal to the average landings but a sum.

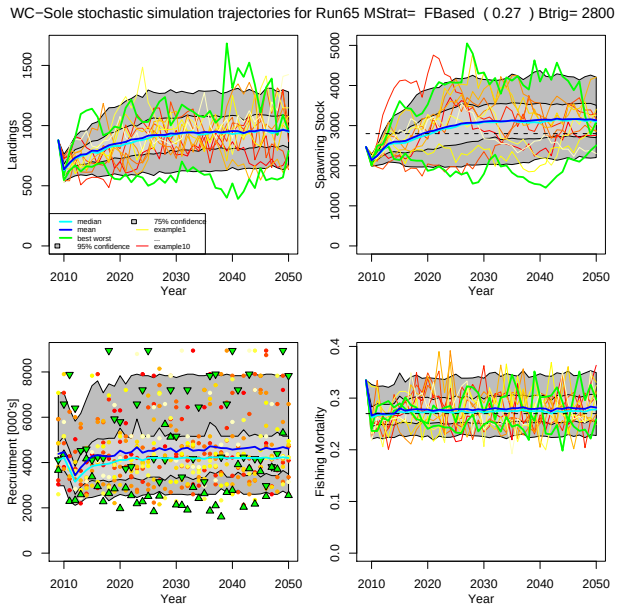

Figure129: Four plot summary results for simulations for Run65. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

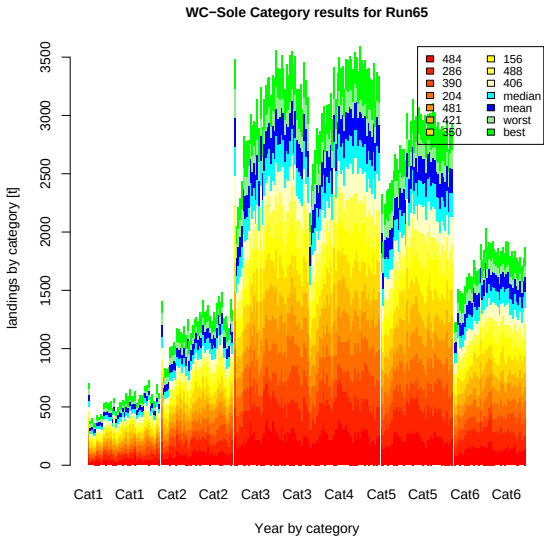

Figure130: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run65. Note that the height of the stacked bars is not equal to the average landings but a sum.

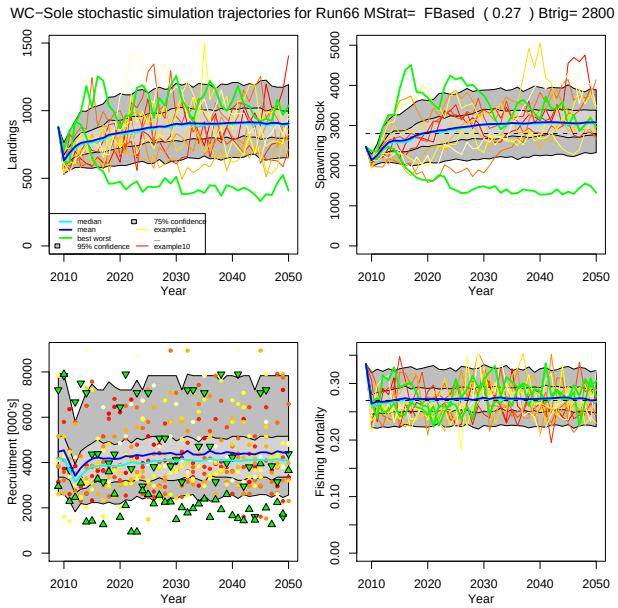

Figure131: Four plot summary results for simulations for Run66. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

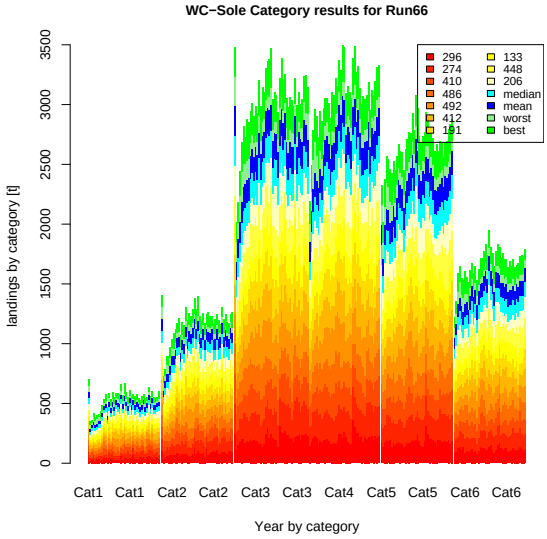

Figure132: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run66. Note that the height of the stacked bars is not equal to the average landings but a sum.

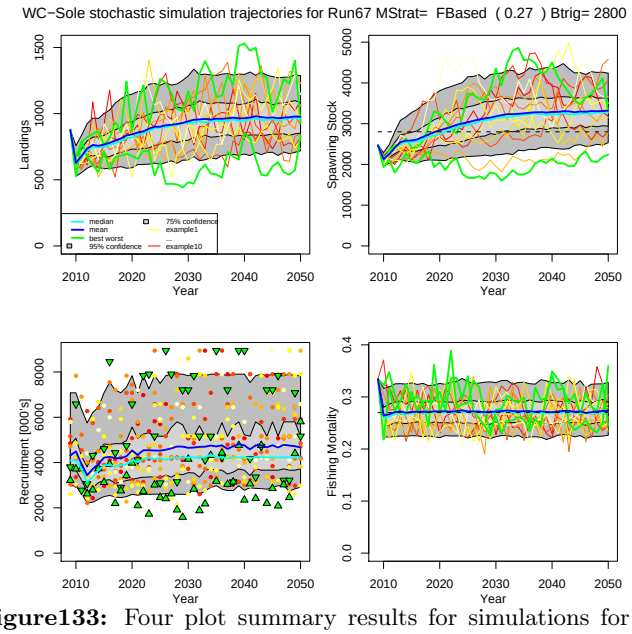

Figure133: Four plot summary results for simulations for Run67. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

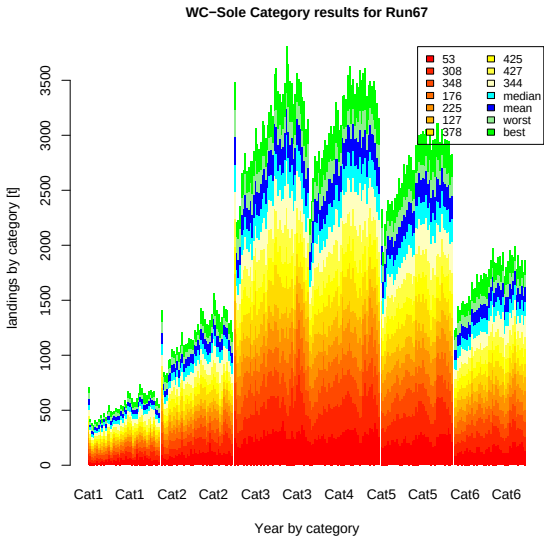

Figure134: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run67. Note that the height of the stacked bars is not equal to the average landings but a sum.

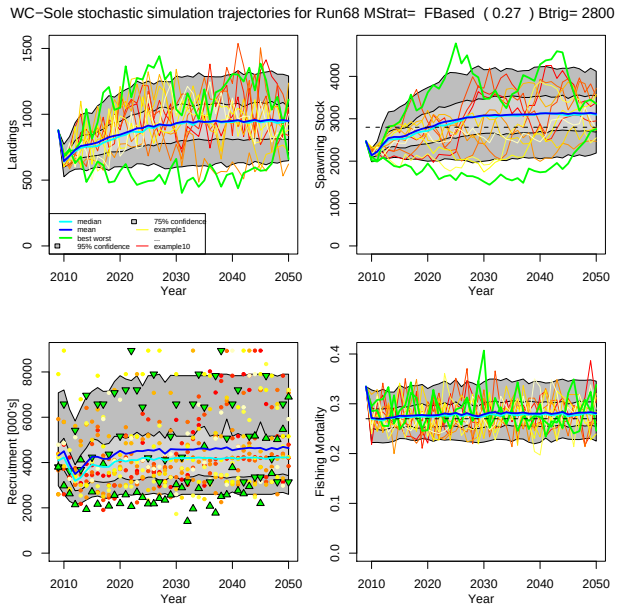

Figure135: Four plot summary results for simulations for Run68. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

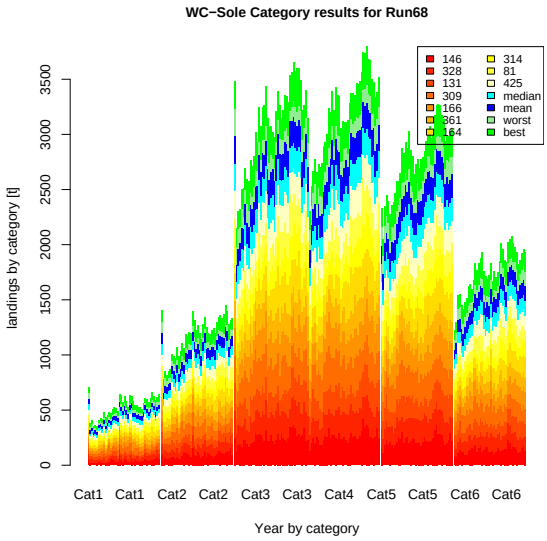

Figure136: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run68. Note that the height of the stacked bars is not equal to the average landings but a sum.

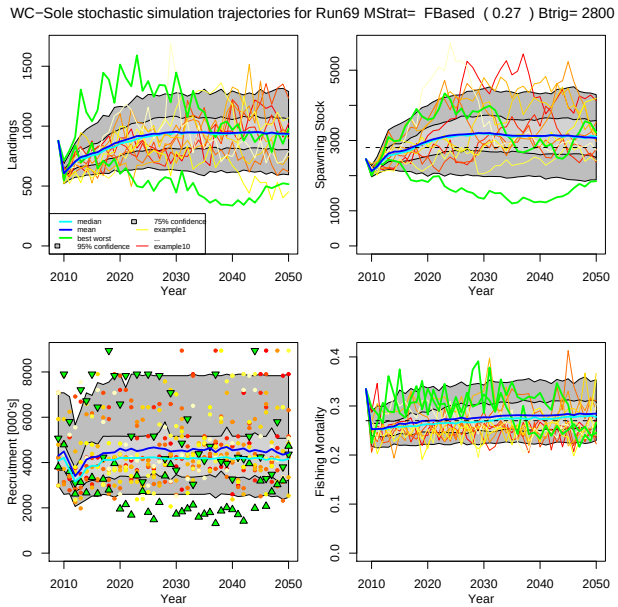

Figure137: Four plot summary results for simulations for Run69. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

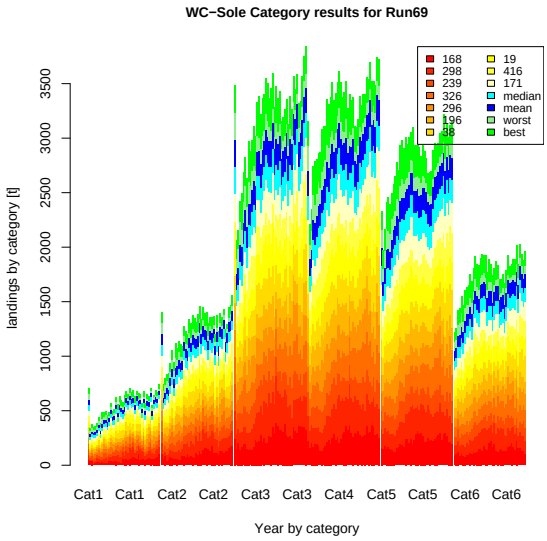

Figure138: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run69. Note that the height of the stacked bars is not equal to the average landings but a sum.

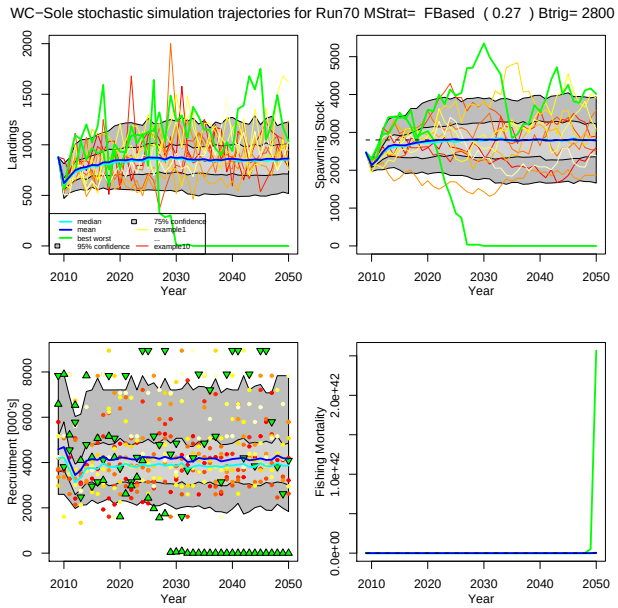

Figure139: Four plot summary results for simulations for Run70. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

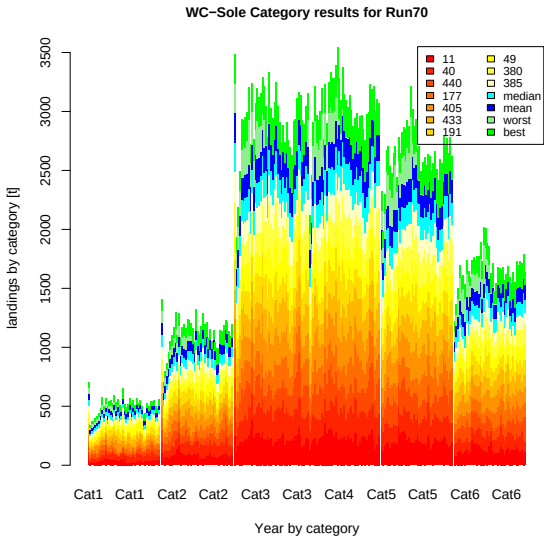

Figure140: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run70. Note that the height of the stacked bars is not equal to the average landings but a sum.

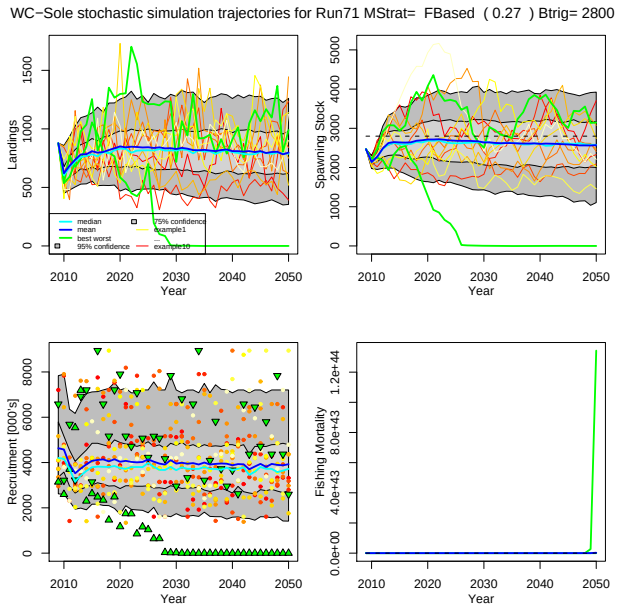

Figure141: Four plot summary results for simulations for Run71. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

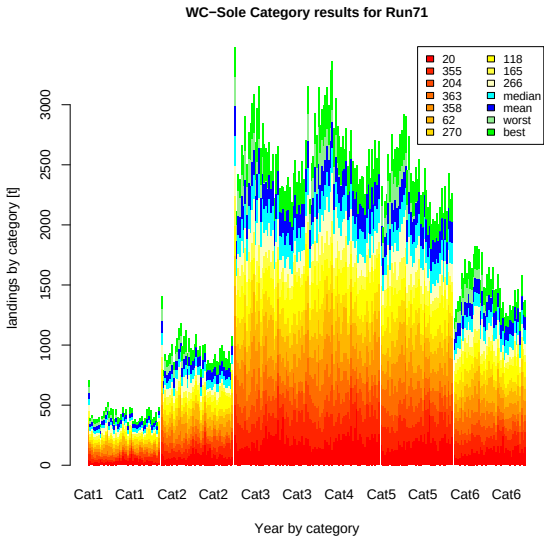

Figure142: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run71. Note that the height of the stacked bars is not equal to the average landings but a sum.

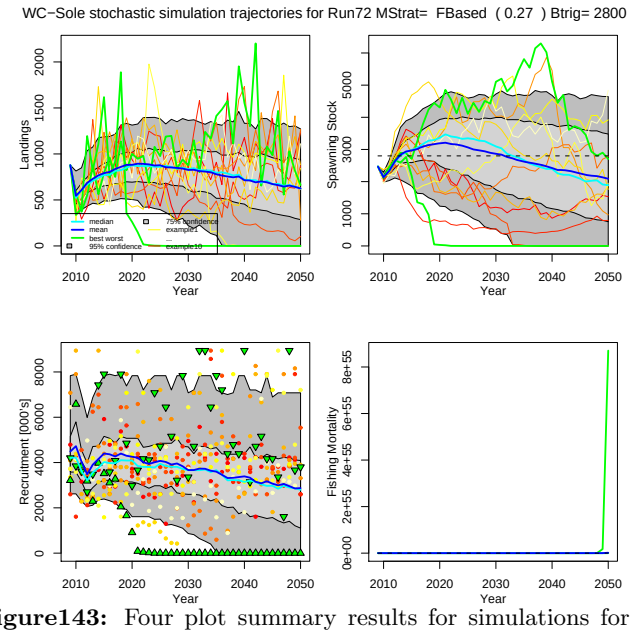

Figure143: Four plot summary results for simulations for Run72. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

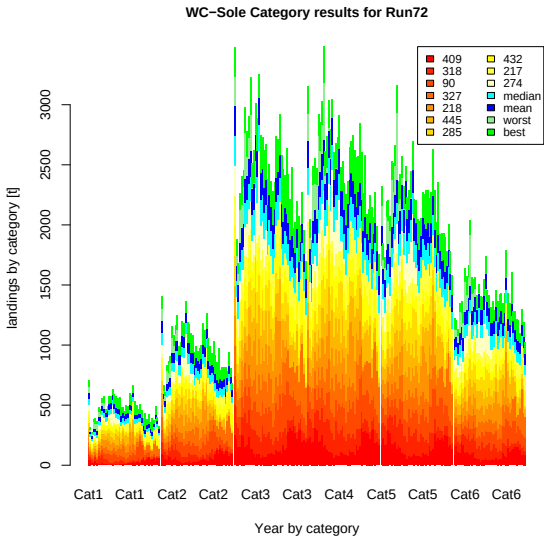

Figure144: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run72. Note that the height of the stacked bars is not equal to the average landings but a sum.

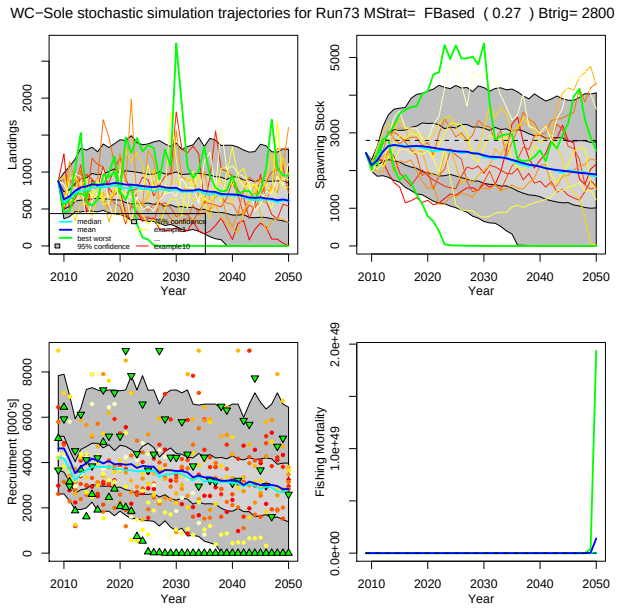

Figure145: Four plot summary results for simulations for Run73. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

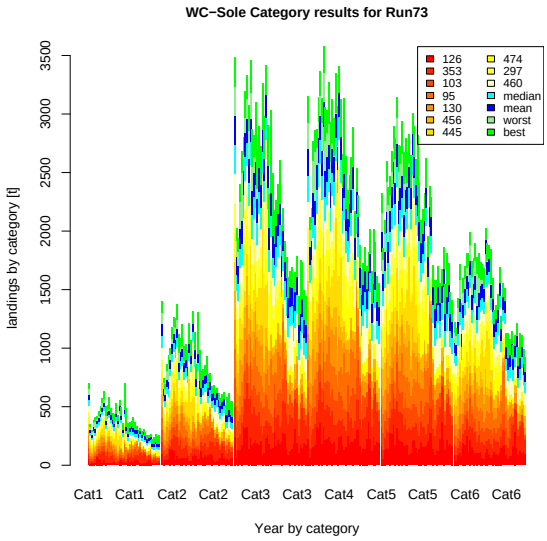

Figure146: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run73. Note that the height of the stacked bars is not equal to the average landings but a sum.

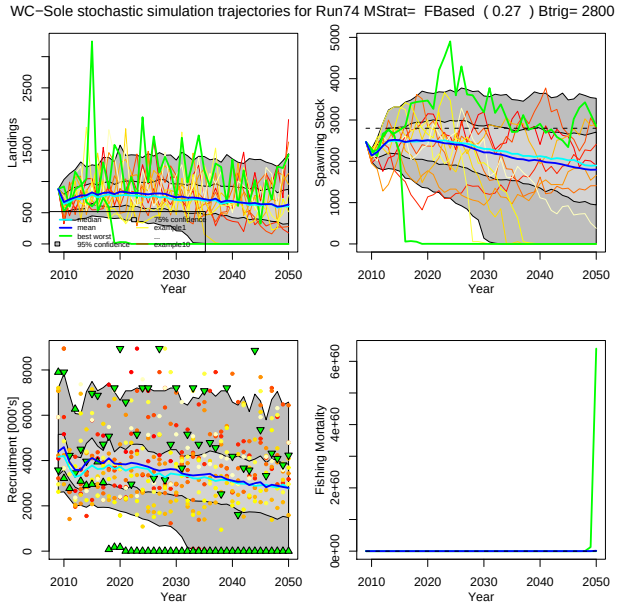

Figure147: Four plot summary results for simulations for Run74. Indicating the 75% and 95% conrfidence limits, mean and median results, best and worst case (min and max of the sum of landings) and worm plots of 10 randomly selected individual simulations

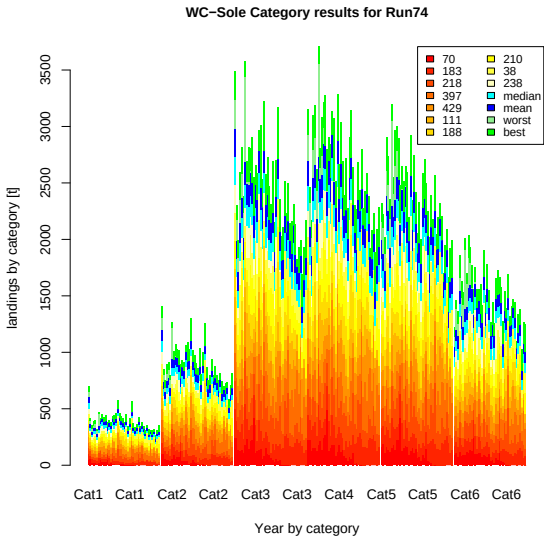

Figure148: Stacked bar arts change in the contribution of landings in each category over the period of the management plan for mean median, best and worst case (min and max of the sum of landings) and ten randomly slected individual samples for Run74. Note that the height of the stacked bars is not equal to the average landings but a sum.

ANNEX C: DYNAMIC EQUILIBRIUM DIAGNOSTICS FOR WC SOLE

WD for SGMOS 10-06 Vigo 18-22 October 2010, EJ Simmonds, European Commission, JRC, Ispra Italy

1. The objective

To provide summary of historic exploitation, and stochastic equilibrium exploitation with estimates of probability of F=Fmsy.

This is not a Management Strategy Evaluation (MSE). The methodology does not include implementation or measurement errors or and restrictions on catch variability to provide economic stability. It provides a general diagnostic of exploitation under fixed target Fs and does not include out of equilibrium conditions that would exist under MSE. Thus it gives a guide for targets and range of outcomes in an error free world. It also provides a comparison with other methods to check calculations.

2. Data and Methods

Data

Data is taken from ICES 2010 assessments of WC sole (ICES 2010a) using SSB/R pairs from 1969-2005. The uncertainty in modeling is limited to match variability used in the assessment data.

Populations are parameterized as 1000 separate populations that includes:-

Selection at age in the fishery drawn at random 1988-2008

Weights at age in the catch drawn at random 1988-2008

Weights at age in the stock drawn at random 1988-2008

and as they are not varying in the assessment does not include variability in the following:-

Annual variability in maturity

Annual variability in time of spawning

Annual variability in timing of fishery

Annual variability in natural mortality

Recruitment simulation

Recruitment is modelled though stochastic multiple model based simulation for the populations. Models are fitted in FLR. Two models are used are both of Hockey-Stock form

Hockey-stick model	$\exp(\log(A*B)+RND(\sigma))$	(SSB>B)
	$\exp(\log(A*SSB)+RND(\sigma))$	(SSB<B)

Population Simulation

The methods used conform to the methods described in ICES 2010b and matches the population dynamics fitted in the assessment. Simulation of exploitation is carried out at a range of constant F exploitation with selection at age as described above. The populations are taken to equilibrium by exploitation for 100 years and run a further 50 years to obtain equilibrium values for distribution of recruitment, SSB, catch and landings.

3. Results

Recruitment models

The fitted models are shown in for the two options for W C sole.

1) Recruitment dependent on temporally changing external influences. Hockey Stick S/R fitted to mean with point of inflection on lowest observed biomass (ignoring recent years 2006 onwards) – 2,720 tonnes (sigma for S/R variation around mean) (Figure 1)
2) Recruitment dependent on SSB. Hockey Stick S/R fitted to data series (Figure 2)

Population Simulation

The results of the equilibrium exploitation are shown in Figures 4 and 5 for NS sole and plaice respectively. For WC sole catches and landings are assumed to be equal. These plots show the equilibrium conditions, for comparison the historic values of Recruitment SSB and catch are shown against F. It is important to remember that these can be under non-equilibrium conditions. So historic observations to the right of the lines imply outcomes with declining stock and points below or to the left imply expanding stock.

Estimates of optimal exploitation

The optimal exploitation F for these stocks, under conditions of zero measurement and implementation error, can be obtained from these diagrams. An optimal F that is unbiased in the sense that the probability of it being too high or too low is equal (i.e. 50%) can be obtained from the median of the distribution in panel d (see values in Table 1). Taking into account the weight of landings the value balanced across all outcomes is obtained as the F giving maximum mean landings. For both WC sole these two estimates are the same. But depend on the choice of S-R relationship, the fitted value (option 2) implies lower resilience and benefits from reduced exploitation giving a lower Fmsy of 0.2 compared to F0.25 for the S-R relationship with a forced breakpoint at lowest observed biomass. For full management strategy evaluations uncertainty in measurements and implementation need to be included. Such errors result in the optimal exploitation point occurring away from the target value. For WC sole the mean catch/landings curve is domed (Figures 3 and 4), with a steeper declining slope F greater than the maximum than at F lower than the maximum. The probability of being below Blim rises quickly if F is increased due to measurement or implementation errors because the F for 5% probability of SSB<Blim is close to the F for maximum exploitation (Figure 3 and 4). In this case both because of the proximity of the 5% probability of SSB<Bloss and because of the asymmetry in the shape of the landing-F curve a lower more precautionary F will be required.

Table 2 Estimates of F for maximum landings under equilibrium exploitation for WC sole.

	Distribution of F giving maximum landings	Average Landings
	Median	Maximum Mean
Option 1	0.25	0.25
Option 2	0.20	0.20

4. Conclusions

The approach described here provides a way to include gives a baseline for management simulations, but does not take into account the errors that need to be included in MSE or any social or economic targets for fisheries. It provides a check that

5. References

ICES. 2010 Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 12 20 May 2010, Copenhagen, Denmark. ICES CM 2010/ACOM:12.

ICES 2010 Report of the Workshop on Implementing the ICES FMSY framework (WKFRAME) ICES CM 2010/ACOM:54

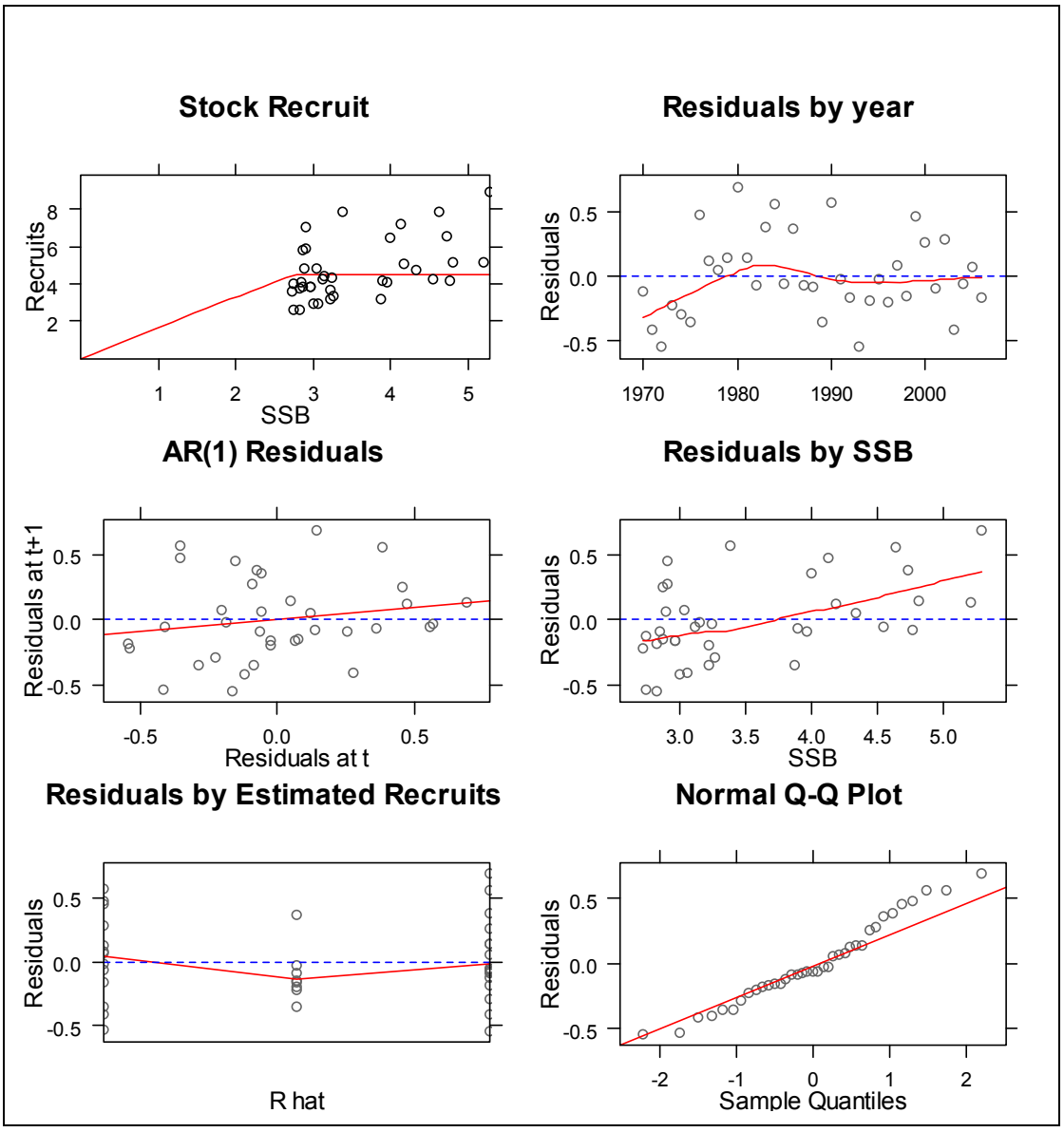

Figure 1 Stock/Recruit models for Western Channel sole: Option 1

Recruitment dependent on temporally changing external influences. Hockey Stick S/R fitted to mean with point of inflection on lowest observed biomass (ignoring recent years) – 2,720 tonnes (sigma for S/R variation around mean) data series1969-2005 (circles).

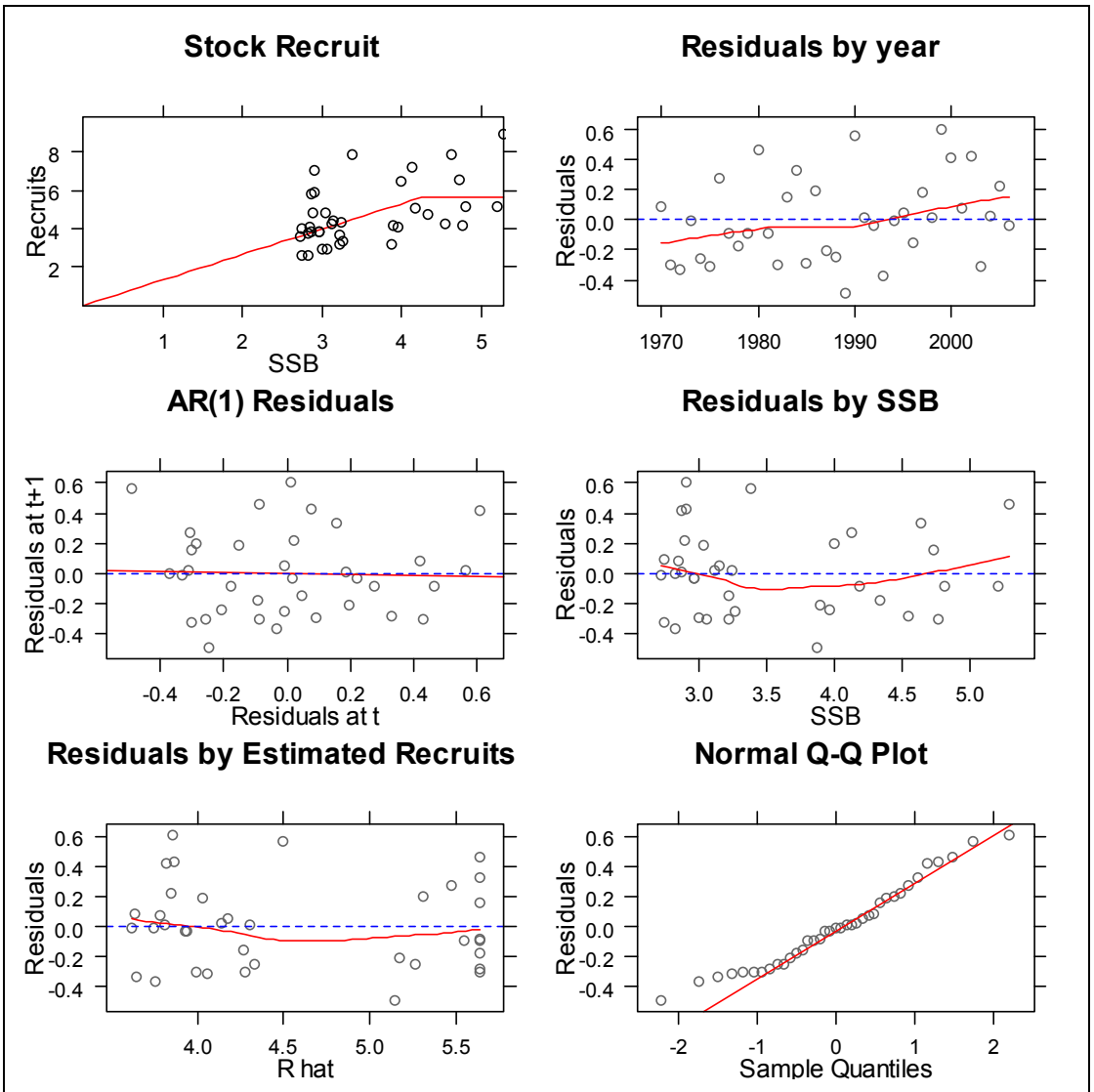

Figure2 Stock/Recruit models for Western Channel sole: Option 2.

Recruitment dependent on SSB. Hockey Stick S/R fitted to data series 1969-2005 (circles).

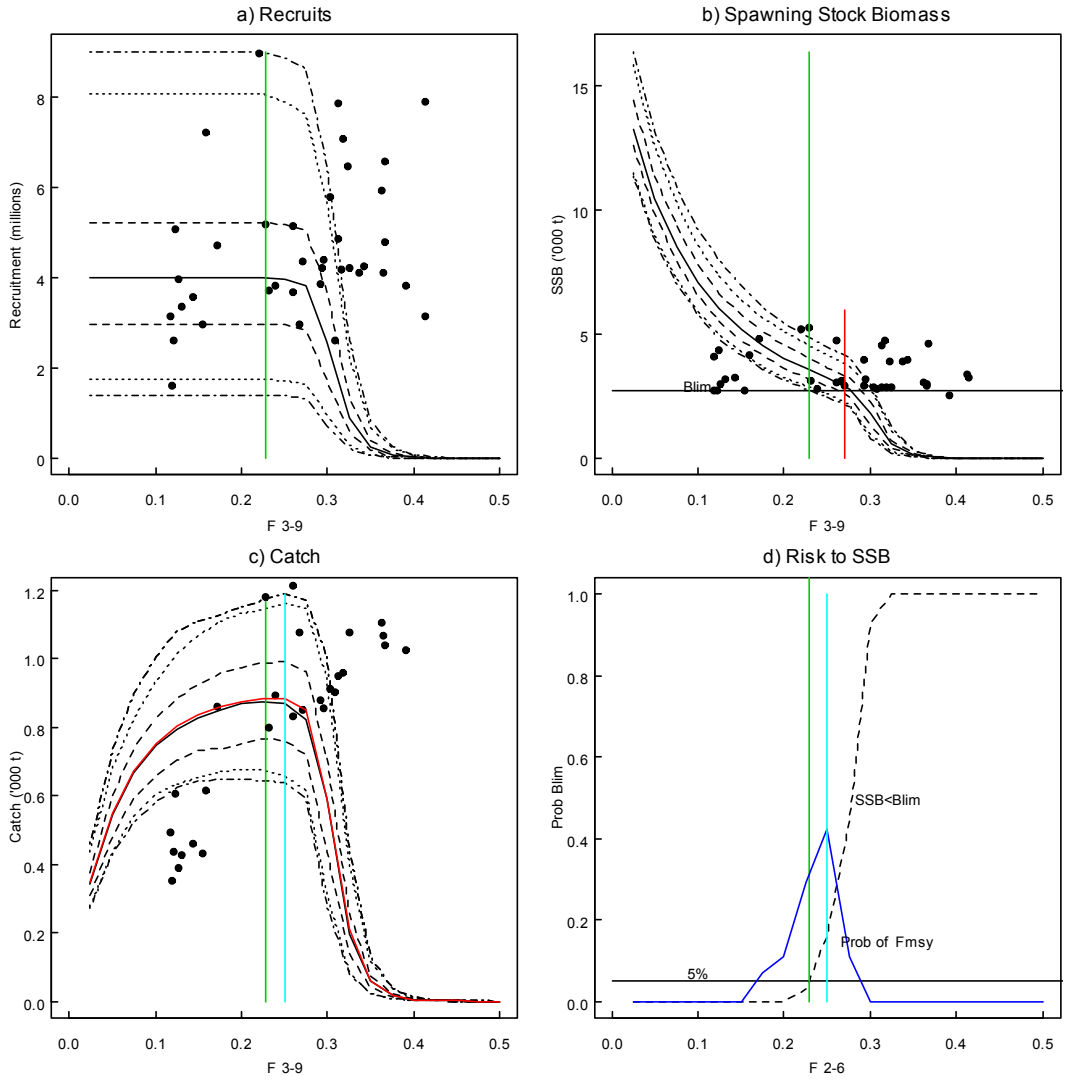

Figure 3 Option 1 Equilibrium exploitation of WC sole against target F from F=0.05 to 1.0. Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch/Landings: black lines. Historic Recruits, SSB and Catch/Landings black dots. c) mean catch/landings: red line. d) probability of SSB below Blim and Bpa: black lines and 5% probability of SSB below Blim green line in all panels. d) distribution of F for maximum catch/landings blue line. F for maximum catch/landings: cyan line, based on 50% point on distribution of F panel (d) and maximum mean catch/landings panel (c) The red line in panel b shows the current management plan target F.

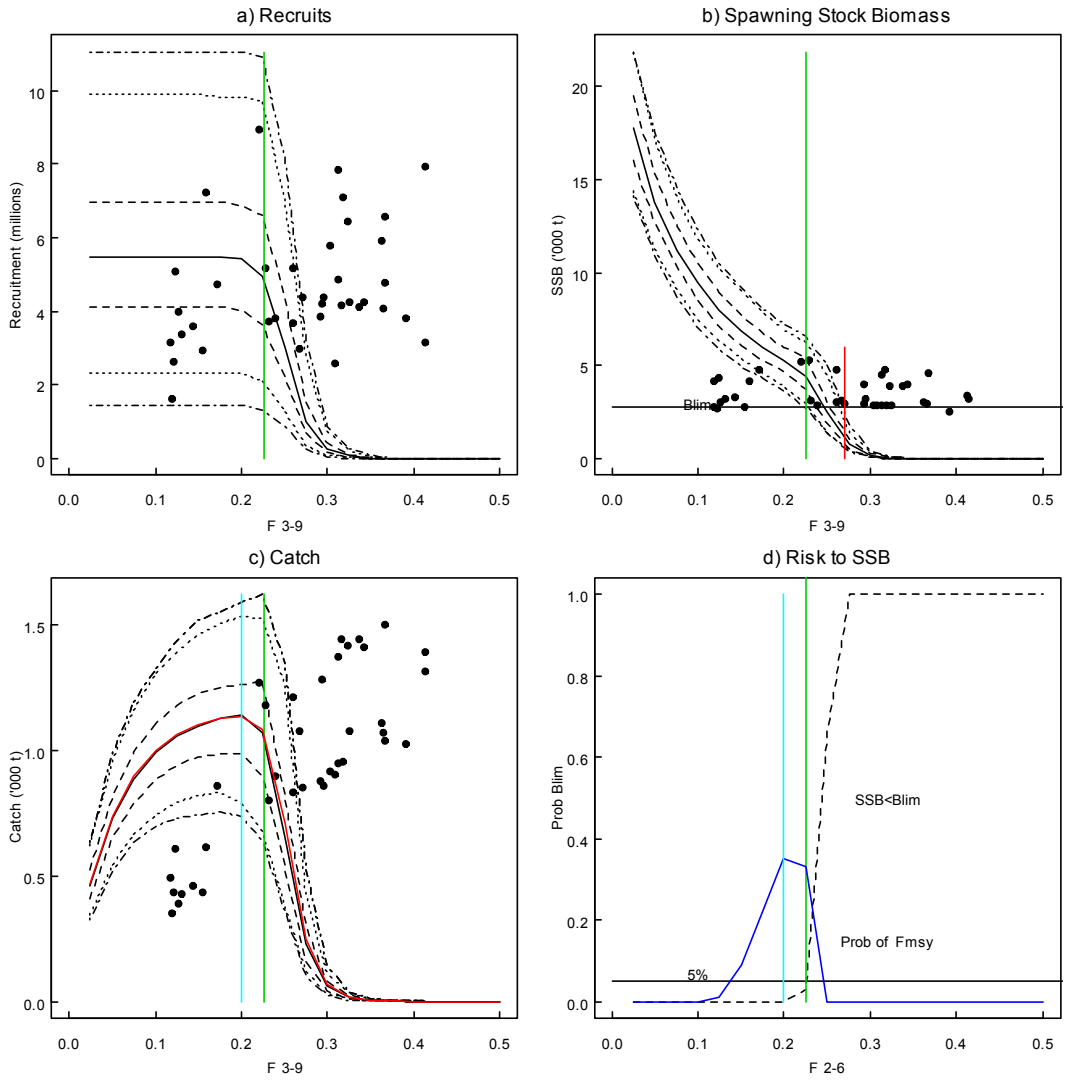

Figure 4 Option 2 Equilibrium exploitation of WC sole against target F from F=0.05 to 1.0.Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch: black lines and Landings pink lines. Historic Recruits, SSB and Catch: black dots. c) mean landings: red line. d) probability of SSB below Blim and Bpa: black lines and 5% probability of SSB below Blim green line in all panels. d) distribution of F for maximum catch, blue line, and maximum landings, pink line. F for maximum Landings: cyan line, based on 50% point on the distribution of F panel (d) and maximum mean Landings panel (c). The red line in panel b shows the current management plan target F.

ANNEX D ECONOMIC STATUS 2008

Data on 431 UK vessels that report catches of WC sole were supplied by SEAFISH UK. This data was used to identify fleet segments with significant catches of WC sole. The value of sole by fleet segment is given in Table D1, the number of vessels with data in the fleet segment (D2) and the percentage of landing value attributed to WC sole in Table D3. Three fleet segments were identified with significant percentages of landings value coming from WC sole: South West beamers 221kw and under (17 vessels); South West beamers over 221kw (26 vessels); Low activity under 10m (117 vessels). Table D1 shows that only 1.7% of the UK landed value of WC sole is taken by the under 10m class. There is little economic data on this segment and they have low overall commercial importance, though they may have some social value. The remaining two segments take 76% of the UK landed value of WC sole. These two segments form the basis of economic evaluation based on the SEAFISH economic data.

Table D1 Value of landings of sole from 7e (Western Channel) by UK fleet segment and percentage of total value of WC sole by fleet segment.

Value of landings of sole in 7e	**Gear Main Code**														
Segment	DRB	FPO	GND	GNS	GTR	HMD	LHP	OTB	OTM	OTT	PTB	PTM	TBB	Value of landings in 7e by segment	% of value of landings in 7e by segment
Area VII scallopers						196641							29700	226341	5.46%
Area VIIDEFG 15-40m											1824		141364	143188	3.45%
Area VIIDEFG trawlers 10-15m	631	690		16246		22111	2845	61154	2557	22455	73	148	19574	148485	3.58%
Gill netters				37858	246		732							38836	0.94%
Low activity over 10m							2	141					3162	3305	0.08%
Low activity under 10m		22399	1845	22493	2142	1181	16743	4311						71115	1.71%
Miscellaneous	221								154					375	0.01%
NSWOS demersal over 24m													14337	14337	0.35%
NSWOS demersal under 24 over 300kw								26356						26356	0.64%
NSWOS demersal under 24 under 300kw		1309						36662						37971	0.92%
NSWOS scallopers						14518								14518	0.35%
Pots and traps 10-12m		28456		77										28533	0.69%
Pots and traps over 12m		201						432						633	0.02%
South West beamers 221kw and under													1431250	1431250	**34.51%**
South West beamers over 221kw*													1719169	1719169	**41.45%**
Under 10m demersal trawl/seine		8892		6045		12164	2870	9587	963	3103	438		4564	48627	1.17%
Under 10m mobile other		3737		5799		2459	64						14454	26514	0.64%
Under 10m passive other		48593	307	42357		19004	14793	1905.1						126959	3.06%
Under 10m pots and traps		37977		2606		810								41392	1.00%
Value of landings in 7e per gear type	852.5	152255	2152	133482	2388	268889	38049	140547	3674	25558	2334	148	3377575	4147904	100.00%

*the % of total value of landings of sole in 7e (Western Channel) caught by the South West beamers (under and over 221kw) amounts to 75.95%

Table D2 Number of vessels catching sole from 7e (Western Channel) with economic data by UK fleet segment.

Number of vessels in 7e	**Gear Main Code**													
Segment	DRB	FPO	GND	GNS	GTR	HMD	LHP	OTB	OTM	OTT	PTB	PTM	TBB	Total per segment
Area VII scallopers						18							1	19
Area VIIDEFG 15-40m											1		1	2
Area VIIDEFG trawlers 10-15m	1	1		3		7	2	19	2	7	1	1	3	47
Gill netters				14	2		1							17
Low activity over 10m							1	1					3	5
Low activity under 10m		**40**	**1**	**33**	**1**	**5**	**24**	**13**						**117**
Miscellaneous	1								1					2
NSWOS demersal over 24m													1	1
NSWOS demersal under 24 over 300kw								1						1
NSWOS demersal under 24 under 300kw		1						3						4
NSWOS scallopers						3								3
Pots and traps 10-12m		4		1										5
Pots and traps over 12m		2						1						3
South West beamers 221kw and under													17	17
South West beamers over 221kw													26	26
Under 10m demersal trawl/seine		6		5		5	3	13	1	1	1		1	36
Under 10m mobile other		2		1		4	1						2	10
Under 10m passive other		31	1	16		12	22	1						83
Under 10m pots and traps		29		2		2								33
Total per gear	2	116	2	75	3	56	54	52	4	8	3	1	55	431

Table D3 Percentage of total value of landings due to sole in 7e by segment and gear and total for segment.

	Gear Main Code												
Segment	DRB	FPO	GND	GNS	GTR	HMD	LHP	OTB	OTM	OTT	PTB	PTM	TBB
Area VII scallopers						2.65%							19.34%
Area VIIDEFG 15-40m											0.47%		24.16%
Area VIIDEFG trawlers 10-15m	0.48%	0.76%		7.97%		2.64%	2.13%	2.83%	1.74%	1.90%	0.03%	0.43%	5.91%
Gill netters				2.66%	0.07%		0.28%						
Low activity over 10m							0.06%	1.75%					6.90%
Low activity under 10m		**13.71%**	**24.37%**	**32.05%**	**87.75%**	**3.85%**	**19.95%**	**24.81%**					
Miscellaneous	0.13%								0.04%				
NSWOS demersal over 24m													9.21%
NSWOS demersal under 24 over 300kw								4.42%					
NSWOS demersal under 24 under 300kw		3.29%						9.38%					
NSWOS scallopers						1.05%							
Pots and traps 10-12m		4.45%		0.18%									
Pots and traps over 12m		0.36%						2.68%					
South West beamers 221kw and under													**19.45%**
South West beamers over 221kw													**10.30%**
Under 10m demersal trawl/seine		2.66%		2.37%		2.83%	2.63%	2.00%	0.62%	2.36%	1.59%		20.74%
Under 10m mobile other		10.49%		8.75%		1.24%	0.41%						5.48%
Under 10m passive other		5.81%	2.11%	7.07%		1.41%	4.03%	16.32%					
Under 10m pots and traps		2.42%		7.57%		1.71%							

ANNEX C DECLARATIONS OF EXPERTS

Declarations of invited experts are published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with the final report.

European Commission

EUR 24630 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Scientific, Technical and Economic Committee for Fisheries. Report on the meeting on Multi-annual Plan Evaluations Impact Assessments: c) Impact assessment of Western Channel sole multi-annual plan

Author(s): John Simmonds, Heleen Bartelings, Jörg Berkenhagen,,Jose Maria Da Rocha Alvarez, Margit Eero, Leyre Goti, Joakim Hjelm, Tore Jakobsen, Sven Kupschus, David Miller, Arina Motova, Rasmus Nielsen Tom Peatman, Tiit Raid, Robert Scott, Cristina Silva, Valentin Trujillo, Willy Vanhee and Christopher Zimmermann

Luxembourg: Publications Office of the European Union
2010 – 128 pp. 21 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1831-9424
ISBN 978-92-79-18744-5
doi:10.2788/55305

Abstract

This report is one five parts of the report of SG MOS 10-06, the STECF sub group on management objectives and strategies dealing with historic Evaluations of and future Impact Assessments of multi-annual plans for fisheries. In total five separate reports are prepared by STECF-SGMOS 10-06 WGs, the first, scoping meeting report STECF-SGMOS 10-06a. contained preparatory work, the other four report the individual assessments:-

STECF-SGMOS 10-06b Report of the Impact Assessments for North Sea plaice and sole multiannual management.

STECF-SGMOS 10-06c Report of the Impact Assessments for Western Channel sole multiannual management.

STECF-SGMOS 10-06d. Report of the Evaluations of Southern hake and Nephrops Multi-annual plan

STECF-SG MOS 10-06e. Report of the Evaluations of Baltic cod Multi-annual plan

This report describes an Impact Assessment of the performance of the multi-annual plan for fisheries of Western Channel sole.

How to obtain EU publications

Our priced publications are available from EU Bookshop (http://bookshop.europa.eu), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

LB-NA-24630-EN-N

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

JRC
EUROPEAN COMMISSION

The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

Publications Office

ISBN 978-92-79-18744-5

9 789279 187445